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A Job to be Done
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ECEMBER
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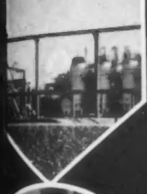

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A SCIENCE SERVICE PUBLICATION

A Job to be Done

➤ THE FLASHINGS of the two Russian satellites in the skies have had a tremendous influence on the public's view of science and technology. Perhaps the prestige of scientists and engineers will rise. If not too much is expected of them toward solving the immediate crises in world affairs (which means first of all preventing atomic war), all may be well.

It should be pointed out that no matter what is done about science education, reinforcing basic or pure research, getting more youths to become scientists, paying teachers more, etc., all will be lost if the H-bombs are let fall with a figurative button-push. Peace, armed though it be, is the first requirement.

Assuming that peace will continue, there is good reason to consider a thousand and one plans for improving science, technology and education. Congress will have hundreds of bills on education and science introduced when it convenes. More millions, not large when compared with the major defense funds, will be appropriated.

These things seem appropriate:

Encourage boys and girls to experiment in science and reach out and find many more at the earliest possible ages who have the abilities to be scientists of the future.

Upgrade and encourage our teachers of science. This means more pay, more appreciation and more help like the summer institutes for science teachers funded by Congress through the National Science Foundation.

Arrange for teachers and cooperating groups in the community, not necessarily in the school system themselves, to conduct at local levels the tests and inquiries that spot the scientifically talented. An immense nation-wide testing program may not be justified.

Give more support to colleges and universities so that they can through their institutionally administered scholarships assure that everyone capable does have a chance to go to college.

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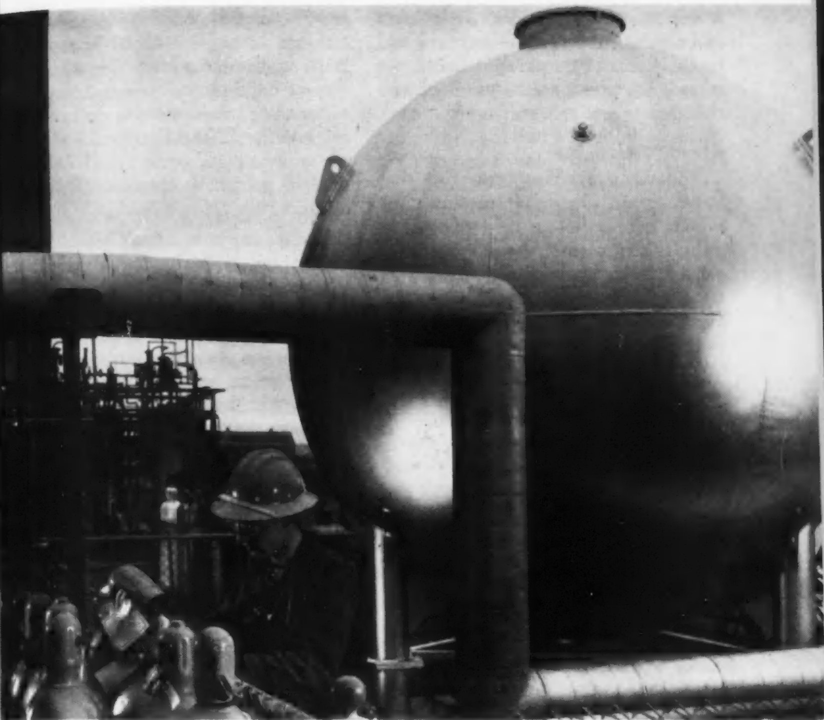


▸ NITROGEN *used in the production of exotic fuels is stored in this large sphere at Olin Mathieson Chemical Corporation's Niagara Falls high energy fuel plant.*

Green Light For Air Power

by HARLAND MANCHESTER

▸ IN 1881 a California "desert rat" named Aaron Winters heard that there was a fortune in the white borax crystals known as cottonball, which he was sure he had seen in Death Valley. He and his wife took some of the stuff to their dugout, gave it a standard chemical treatment and touched a match to it.

"She burns green! Rosie, it's borax! We're rich!" he shouted. And so, Winters joined other prospectors in opening up the great California borax mines of "20-Mule-Team" fame,

source of soap powder, drugs and chemicals used widely in industry and in the home. The pioneers could not foresee the exciting new use for borax that has recently been found.

Green-Burning Fuel

Today, an aviation super-fuel that burns green, derived from this same mineral, is the hottest development in military flying since the advent of jet planes. Tests show that it can drive aircraft farther and higher than the most advanced petroleum fuels, and since more than 90 percent of the world's known borax deposits are in California, the future of American fighting craft looks rich indeed.

Tanks of the new "exotic fuel," as it is called, are being shipped from pilot plants to the Air Force and the Navy, and four production plants are being built at a cost of 88 million dollars in New York, Oklahoma and Kansas.

In a semi-commercial pilot plant of the Olin Mathieson Chemical Corp., located within sound of Niagara Falls, I watched the jade-green exhaust plume of the new superfuel as it spurted from a small, stationary jet burner, equipped with instruments to meter the fuel and record the heat generated as it burns. The most significant factor in any fuel designed for reaction motors — a term which includes jets, missiles and rockets — is the amount of heat released by a pound of it.

After preliminary tests of this fuel in a ramjet under simulated conditions of 60,000 feet and a speed of 2100 miles per hour, the Lewis Flight Propulsion Laboratory at Cleveland recently reported that it should extend the range of this missile 40 percent beyond that provided by the best petroleum fuels. This could be roughly translated to mean that if an oil-burning jet bomber with a range of 5000 miles were fired with the new chemical, another 2000 miles would be added to its range, or it could carry a load 40 percent heavier for the same distance.

Studies of "exotic fuels" for jet aircraft were made by the British ten years ago, but the work which led to boron fuel production began in 1952, when experts of the Navy Bureau of Aeronautics and the Air Force laid their problem before chemical and oil company leaders. Jet planes, although vastly superior to piston planes in speed and rate of climb, are gluttons for fuel. The weight of the fuel load has always limited their range and lengthened their take-off space. What the services needed was a fuel with more energy which would behave like the jet's kerosene-like fuel in every other respect. Two firms were given contracts to proceed with the study: Olin Mathieson and the Callery Chemical Company near Pittsburgh.

Hydrazine Experience Helped

Olin Mathieson had had long experience making explosives and ammunition, and had already tamed and placed in production the powerful hydrazine-based rocket fuels which will be used to lift the U. S. satellite into space. Dr. L. K. Herndon, a former professor of chemical engineering at Ohio State University and Director of Research for Mathieson, had headed the hydrazine project, and he was chosen to look for the new superfuel.

"I told the Defense Department we would spend two years trying to find

out whether such a fuel was practical," said Dr. Herndon. "If it didn't look promising we would write it off completely, and if we thought it could be done we would draw up plans for big-scale production. The first thing we did was to take a hard look at the table of elements."

Hydrogen, which produces nearly three times as much heat per pound as any petroleum fuel, topped the list. When your car burns gasoline (a combination of carbon and hydrogen) hydrogen provides most of the power. Pure hydrogen might appear the ideal fuel, but in its gaseous state it takes up so much room that one would need a balloon for a fuel tank, and in liquid form would require bulky and expensive cooling equipment.

"Since all oil fuels are, in effect, vehicles for hydrogen," said Dr. Herndon, "we searched for a molecule into which we could pack more of it — a better hydrogen bucket." There are many elements which can be combined with hydrogen to make a combustible liquid, so the Herndon team set to work building strange molecules.

Beryllium Ruled Out

They first thought of beryllium, which packs tremendous heat and combines well with hydrogen, but the metal is scarce and expensive and its exhaust product is highly toxic. Boron compounds — based on the same borax from which the soap ingredients and eyewash are obtained — looked most promising, even though some of the production stage compounds also are highly toxic. They far surpass oil in heat production and are made from cheap and plentiful raw materials. Laboratory research reports were favorable, and in the spring of 1954, Dr. Herndon was able to tell Defense Department fuel and aviation leaders that the superfuel could be made. Soon after, contracts were awarded to build large-scale plants, all of which are planned so that they can be greatly expanded as demand warrants. Other undisclosed millions are said to be staked on the green revolution.

So Much Eyewash

Details of manufacture are secret, but the process starts with the mild boric acid solution similar to that sold as eyewash in drug stores. From this is produced a powerful and obstreperous gaseous compound. Passing in several steps through a maze of pipes, valves and tanks, this is tailored into the high-energy fuel and tamed so that it can be handled safely. Great precautions are used. Refrigeration keeps the stuff under control during the early violent stages, and the plants are subdivided by fire walls to limit the effects of accidents.

The fuel emerges as a transparent liquid with a tint ranging from bluish to amber and with a distinctive odor much less pungent than that of gasoline. It does not burn with a hotter flame than oil; its chemically locked-up heat units are burned at the same rate, but there are more of them and a gallon lasts longer. Engineers state that in all other respects it meets the specifications of oil jet fuels.

The exhaust from the superfuel contains boric oxide which crystallizes into fine white grains. Would this be toxic to ground crews? To test it, engineers stuck a jet exhaust pipe into an enclosed trailer truck containing 2000 rabbits, rats and guinea pigs. The animals washed the powder off

their faces, and autopsies four months later showed no tissue changes. Bearing in mind that no engine exhaust is recommended for breathing, engineers concluded that this should present no serious problem.

Planes Can Fly Higher

Higher operational ceilings are another advantage of the new fuel. The flames of oil-fed jets sputter and go out in the thin air at very high altitudes. At a recent demonstration at the Lewis Flight Propulsion Laboratory, two experimental jets, one fed with oil, the other with the boron fuel, were run side by side in simulated high-altitude conditions. The green boron flame continued to burn steadily long after the yellow oil flame had expired. This offers boron-fed craft an immense tactical advantage.

It is expected that the superfuel will be used first in missiles, ramjets and the afterburners mounted on the tails of jets to give them added bursts of speed when needed. At present there is a tendency for the liquid boric oxide liberated in combustion to gum up turbine blades, and the problem must be solved before boron-fueled jet bombers take off. Also, jet engines must be redesigned to use the fuel, but tests are now under way.

Meanwhile it is widely reported that a boron fuel may feed the jets of the projected WS-110A, a giant bomber now on the drafting boards of the Boeing Airplane Company and North American Aviation, Inc., a high-flying, high-speed, heavy payload craft which, in North American's words, "may revolutionize Strategic Aircraft Command concepts and operations."

Research continues, and Dr. Herndon expects even more efficient and powerful fuels. "We expect to get half as much heat per pound from a boron fuel as can be obtained from the perfect fuel, hydrogen," he said, "and we will not stop there."

Translated into jet bomber performance, that would mean that a plane like the B-52, whose fuel tanks hold 200,000 pounds, could carry up to 100,000 more pounds of cargo over the same distance, or could fly up to 50 percent more miles without refueling. Last year when the record-breaking B-52s, circled the globe non-stop in 45 hours and 19 minutes, they had to "come downstairs" a number of times for refueling by aerial tankers. A fuel with more heat in it would have cut several hours from their flying time and would have reduced the number of expensive and difficult refueling missions. It would also make bombers much less vulnerable in time of war.

Meanwhile there is great activity on California deserts over which the famous 20-mule teams once hauled borax to market. Wide use of the new flying fuel would more than double the demand for borax, and the U. S. Borax and Chemical Corp., the world's largest producer, has just spent 20 million dollars digging a giant crater in the floor of the Mohave Desert at Boron, California, and building a refinery to process it. This bared for strip mining the world's largest known deposits of the borax ore. Company experts believe there is enough ore in sight to keep planes flying for 50 years, as well as filling all other boron needs.

This article is published in cooperation with READER'S DIGEST

Rockets Urged For Upper Air Studies

➤ Using rockets to spread chemicals high in the earth's atmosphere not only creates luminous, man-made clouds but may be a method of measuring temperatures far above the earth's surface.

Chemical seeding to learn about the air's composition and structure has been recommended to a National Academy of Sciences meeting by Dr. Joseph Kaplan, University of California physicist who heads the U. S. program for the International Geophysical Year.

(Dr. Kaplan once suggested that a rocket put in orbit around earth some 60 or 70 miles out could be powered by the chemical energy stored there. The possibilities of such a "low altitude" satellite are now being intensively studied by the Air Force. Information on conditions in the upper atmosphere gained during IGY is considered essential to development of the solar-powered rocket.)

The chemical make-up of the earth's atmosphere, Dr. Kaplan told the meeting, results mainly from the sun's radiation on gases in the air. One important key to reactions taking place there is the night airglow, a very faint light first discovered by astronomers on long-exposure photographs. Dr. Kaplan reported airglow studies made jointly with Dr. C. A. Bartha, also of the University of California at Los Angeles.

The airglow is too weak to be detected by the eye. It is rather uniformly distributed over the entire planet, but varies in intensity with time and with position in the sky as observed from one point.

The ratio of sunlight to moonlight to airglow is about one million to one to one-millionth. Heights of the layers emitting airglow vary from about 30 to 600 miles. The region is known as the chemosphere.

Many of the reactions taking place in this region produce the faint airglow. During the day, sunlight splits the molecules, including the oxygen, into atoms. At night, the atoms recombine, releasing energy available for causing night airglow. Main radiations are from oxygen and sodium atoms and the hydroxyl, which is an ion of water.

When chemicals are thrown into the upper atmosphere by rockets, the artificial cloud produced is the same as airglow. Both nitric oxide and sodium have been used for rocket seeding.

Laboratory studies of airglow reactions have also been made, Dr. Kaplan said. They showed some radiations still not yet found in the atmosphere were part of the man-made airglow.

A new type of ultraviolet lamp produces a radiation said to be 100 to 1,000 times more effective in killing microorganisms than ultraviolet from the sun.

A series of stalactites in the Luray Caverns of Virginia has recently been "tuned" by grinding away portions of the surface so that they produce organlike music when struck with rubber-tipped hammers.

Chemistry's Contributions
To Every Industry Featured

Exposition of Chemical Industries

by David Purslgove

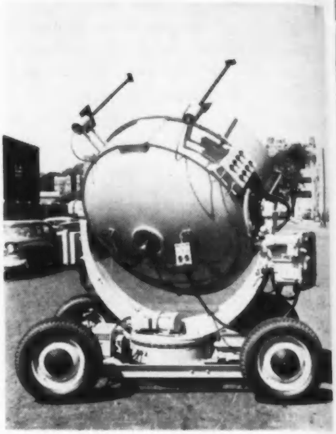
➤ Nearly 40,000 chemists and representatives of chemical industries trooped in and out of New York's gigantic Coliseum during the first week of this month to witness a display of chemicals and chemical processing and laboratory equipment that was notable for several "firsts" and "biggests."

The 26th Exposition of Chemical Industries December 2-6 was the largest of the shows held in the Exposition's 32 year history. It was also the largest event yet to take place in the Coliseum, the first event to occupy all four exposition floors — 669 exhibitors covered 300,000 square feet with nearly 1,400 tons of equipment and apparatus.

The exhibit, which was not open to the general public, was designed to interest primarily the chemical and industrial manufacturer, but also featured enough laboratory apparatus and new chemicals to draw many chemists and invited students.

Something for Every Industry

Some of the industries for which specialized equipment was offered are: mining, cement, metal working, wood finishing and the manufacture of cosmetics, ceramics, industrial and agricultural chemicals; also plastics, stone clay and glass products; drugs and pharmaceuticals, soap, detergents and waxes, synthetic fibers and surgical instruments, to mention only a few.



➤ Solar *furnace (American Searchlight Corp.)*

There was equipment for producing foods and food additives, fungicides and preservatives, confectionary and surgical dressings, biochemical, bacteriological and medical supplies; also pencils and carbon paper coatings, cork products and matches, mills for mayonnaise and asphalt, for flour, rice and chocolate. Paints, paper and the shipbuilding and aviation industries were served.

Mass Produced Sun Furnace

Basic research on structural materials for jet aircraft and space-travelling rockets can be stepped up at more colleges and industrial labora-

tories now that high-temperature sun-powered furnaces are available on a mass production basis. The solar furnaces, mounted on surplus military searchlights, make it possible for more laboratories to conduct high-temperature research without first devoting months to building a solar furnace.

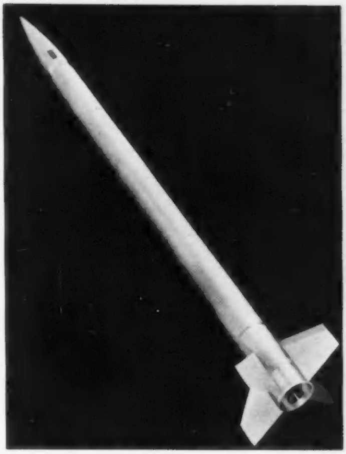
A mass production model of a solar furnace similar to several built recently by research institutions for their own use was displayed at the Exposition.

Gerard J. Wendelken, vice president and general manager of the American Searchlight Corporation which produces the furnace, told CHEMISTRY the new equipment can be afforded by low-budget colleges and research institutions because of a design based on surplus searchlights.

Mr. Wendelken said the mass produced solar furnace sells for $8,500. "The searchlights, which now have very little use in this age of high speed aircraft, originally cost the government around $25,000 each," Mr. Wendelken said. He added that a similar furnace built from new materials would cost the user $40,000 to $50,000 and "would prevent many organizations from participating in much-needed high temperature research."

Solar furnaces use one or more mirrors to bring the sun's rays to a high temperature focus. The mass-produced model reaches temperatures up to 8,000 degrees Fahrenheit.

Sun-powered furnaces are used in many types of high-temperature research because of their low cost of operation and the high temperatures they reach. They are used in research



➤ Arcon *high altitude rocket (Atlantic Research)*

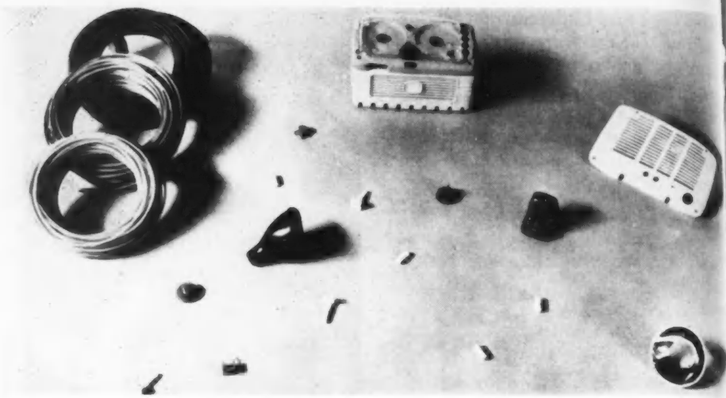
on ultra-pure metals and other jet and rocket materials particularly because they do not contaminate the materials under study.

When strategic materials are melted in even the hardest and most heat resistant crucibles or other containers, small amounts of the container enter the molten material as impurities. The same materials can be suspended at the focal point of a solar furnace and melted in one spot without touching a hot container wall.

Rockets, Too

One of the exhibitors in the Rocket and Satellite Section (Atlantic Research Corp.) displayed a high altitude sounding rocket and its "PET" solid-propellant rocket, probably the world's smallest commercial rocket.

HiCal, a new high energy boron fuel which some sources suspect may be similar to what propelled Sputnik



➤ MOPLEN *polypropylene plastics (Montecatini)*

II into space, was on public display for the first time.

The new fuel, which should power jet aircraft and missiles to new peaks of efficiency and performance, was developed for the Navy by Callery Chemical Co., Pittsburgh, Pa.

Greater energy provided by HiCal can extend the range of aircraft or missiles, reduce the weight of airframes, increase payloads, or improve speed and climb, Callery officials said.

Aluminum Gaining

Chemical process industries will almost double their consumption of aluminum by 1960, a Reynolds Metals Company executive predicted at the opening of the Exposition.

W. B. Moore, manager of the company's chemical and petroleum market, made the forecast at the Reynolds exhibit depicting the growth of aluminum use in the chemical process industries.

The exhibit displayed eight major applications of aluminum, representing consumption of 47 million pounds of the lightweight metal this year. The applications featured were process pipe, heat exchanger tubing, tanks and vessels, hookups for tanks and vessels, insulation jacketing, chemical drums, chain link fencing, and instrument air lines.

The exhibit also highlighted the use of aluminas as raw materials.

"Within the last five years aluminum has been accepted as a major material for construction," Mr. Moore noted. "Previously aluminum was considered only for use in special applications.

"We expect an even greater growth in aluminum use in chemical process industries in the next few years. By 1960 at least 92 million pounds will be used, according to our market projections."

Volume-wise, the greatest increase in consumption was predicted for tanks and vessels and their hook-up lines. Usage for this application is ex-

pected to grow from the present 25 million pounds of aluminum to 45 million pounds in 1960.

New Synthetic Fiber

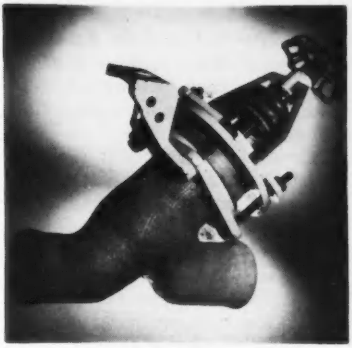
A new man-made fiber that looks and feels like wool, is water repellant and quick-drying like nylon, can be ironed and costs less to produce than any other existing synthetic was publicly displayed for the first time.

A last minute research breakthrough by scientists of the Italian Montecatini organization eliminated final processing bugs that allowed bolts of Moplen fabric and hanks of yarn to be flown to New York in time for the opening of the Exposition. Montecatini representatives in the United States had been unaware of the latest development in a series of fast-moving events surrounding the new fiber and had planned to display only the hard polypropylene plastic from which the fiber is produced.

A Montecatini official from Milan told CHEMISTRY further developmental work must be done and it will probably be over a year before the revolutionary new fabric will be marketed. In the meantime the company is expanding its facilities to produce the basic Moplen plastics which have other uses such as in tubing, containers, packaging, structural materials, etc.

Moplen is one of a series of new plastics "tailored" from propylene gas by a process discovered by Prof. Giulio Natta, professor of industrial chemistry at the Polytechnic Institute of Milan and consultant to Montecatini Societa Generale per l'Industria Mineraria e Chimica.

Unlike polyethylene, the popular squeeze bottle and tubing plastic, polypropylene can be spun into fibers and will resist temperatures considerably above that of boiling water.



➤ PYREX *Y-valve (Corning)*

Chemists can change some characteristics of polyethylene by altering the molecular weight. Several characteristics of polypropylene can be altered simultaneously by varying the plastic's crystalinity as well as molecular weight, Montecatini representatives pointed out. They added that Moplen can be produced as hard or soft, flexible or brittle materials as the chemist desires.

Although Moplen fiber has the hand and appearance of wool, company officials had at first decided not to display it here because of a slight waxy feel that chemists were trying to overcome. The waxiness has been eliminated by a yet undisclosed process.

Among the advantages claimed for Moplen are low density and cost. Moplen is said to be the lightest plastic material produced. Whereas nylon is produced for nearly $1.00 a pound, Moplen is expected to be produced at less than 15 cents.

Ceramics and Glass

The first commercially available tubing of Pyroceram, the new family of crystalline materials, was shown as a feature of the Corning Glass Works exhibit.

The exhibit, the largest the company has had during its 35-year association with the show, also included the latest in glass pipeline and drainline systems for the chemical field.

Pyroceram items shown at the exposition included samples of tubing to be made in commercial quantities after the first of the year.

The newly-introduced Pyrex brand glass Y-type valve, both as a complete unit and in cut-away form, was on display for the first time. Glass fittings available for the chemical industries and laboratories were shown.

New Use for Plastics

A disposable medicine container that becomes a hypodermic syringe for use by diabetics and in first aid kits has been made by a plastics manufacturer for market testing.

A pilot sample of the throw-away plastic container and syringe, which looks like a small transparent toothpaste tube, was displayed by Minnesota Mining and Manufacturing Company's Jersey City Chemical Division which produces the KEL-F plastic from which the product is formed.

Officials of the company's chemical products group told CHEMISTRY the container-syringe made from the heat-resistant plastic can be sterilized in boiling water, in a high pressure steam autoclave or by radiation.

A company official said the high strength imparted to KEL-F plastic by its carbon, fluorine and chlorine molecular structure means a diabetes or heart patient can carry the pre-filled syringe in his pocket without fear of breakage or cracking which would contaminate the contents. Because the plastic is not penetrated by alcohols, essential oils and many other chemicals, the container-syringes can be filled with most medicines.

Minnesota Mining and Manufacturing will not produce the disposable syringes, but is now forming a small quantity of them for a plastics customer who will use the samples to gain opinions from physicians and pharmacists.

Rare Materials

Latest developments in the search by industry for extensive applications for gallium, a little used wonder metal, were displayed by Aluminum Company of America.

Alcoa showed intermetallic compounds of the amazing metal which have generated interest in the field of electronics. Gallium arsenide and gallium phosphide have demonstrated interesting properties for use in transistors, diodes, rectifiers, and other semi-conductor devices.

Gallium will melt from the heat of a person's hand, but will not boil until heated to about 3600° F. And unlike most elements, it expands when it solidifies. Refinements in the processing method now enable Alcoa to produce gallium of better than 99.995 per cent purity.

Also featured in the exhibit were ceramic radomes and nose cones made of Alcoa alumina, the white powder that yields aluminum in electrolytic smelters. Delicate in appearance, the radomes must be transparent to radar waves, and combine strength with high resistance to heat. A promising application is the missile field, where ceramic nose cones appear able to

prevent rocket heads from disintegrating as they re-enter the earth's atmosphere.

Capacitor grade tantalum metal was introduced as the latest product development of Kennametal Inc., Latrobe, Pa.

Bars, sheets, foil and wire made from tantalum of 99.9% purity produced by methods developed by the Latrobe firm were exhibited and announced as available in production volume. In addition to these forms, tantalum metal granules, of the same high purity, will also be made available.

Tantalum of such high purity is being utilized extensively in the manufacture of capacitors required with transistors which are being widely used in radio, television, aircraft, missile, radar, fire control, navigational and other equipment. Behind the adoption of transistors are many advantages including compactness and a reduction in weight over equipment previously used.

Tantalum also is creating interest in the nuclear energy field and is being considered as one of the newer "Atomic Age" materials along with uranium, plutonium, zirconium, niobium and others which have been developed to provide specific metallurgical properties.

High purity tantalum metal has an exceptionally high resistance to some of the most violent corrosive acids and vapors. This characteristic of the metal promises wide adoption in equipment for processing chemicals, pharmaceuticals and foods where freedom from product contamination and harmful reactions are essential.

A special career symposium, sponsored by the Division of Industrial and Engineering Chemistry of the ACS, was held at the Exposition daily with panel discussions for the benefit of qualified students of chemistry and chemical engineering.

Hydronium Ion Confirmed

➤ THE EXISTENCE of a complex hydrogen ion that has long been the bane of any person who has studied chemistry in high school or college has been confirmed.

There is no longer any doubt that hydronium ions exist in water solutions and students will have to reconcile themselves to giving the troublesome ion due consideration in their attempts to balance complicated chemical equations.

Drs. Michael Falk and Paul A. Giguere, Laval University, Quebec, confirmed the presence of hydronium ions, H_3O-positive, by infrared spectroscopy. They believe refinements in their technique may make possible more accurate determinations of the degree of ionization, or "strength," of strong acids in concentrated solutions. Until now such measurements could be made only indirectly and frequently without precision.

For over 50 years the hydronium ion has been only a concept found useful in explaining otherwise confusing results in setting up some equations. Students have been told that water in most solutions breaks up to form H^+ ions. This expression has served well to fill in gaps in equations, but sometimes fails to complete more complicated expressions.

Glycerine Flow Sheets Available

➤ THE GLYCERINE Producers' Association is offering chemistry and chemical engineering instructors a wall chart diagramming the production of glycerine from fats and propylene. The chart, intended as a classroom study aid, also lists properties and uses.

The flow sheet brings together for the first time the many different unit processes by which glycerine is manufactured including saponification, hydrolysis, distillation, sodium reduction and ion exchange. Synthesis of glycerine from propylene is also included.

The flow sheets are available free of charge to *instructors* who write the Association at 295 Madison Avenue, New York 17, New York, on their *college or school letterhead*.

Glycerine (or glycerin) is the commercial form of the trihydric alcohol — glycerol. It is a sweet, syrupy, colorless liquid. As marketed, it generally contains a small amount of water, and this moisture-retaining property is one of those responsible for many of its uses as a humectant and product conditioner. Its viscosity, stability and solvent properties are others. U.S.P. Glycerine is acceptable as a pharmaceutical or food additive.

Because of its three reactive hydroxyl groups, glycerine is a basic chemical "building block" used by Nature in the structure of oils and fats (glycerides) and by industry for many derivatives. These range from explosive nitroglycerine to highly resistant resins.

Glycerine has been produced commercially from fats for over one hundred years, as a part of soap making. During the past ten years, glycerine from propylene has grown to meet more than one-third of market requirements. Total U. S. consumption of glycerine is about 250,000,000 pounds a year.

O_2, H_2 Power New Generator

➤ A NEW GENERATOR that produces electrical power directly from the chemical energy of gases has been announced.

The new fuel cells require no gasoline, steam or hand-driven engine to generate electricity. The chemical energy of hydrogen and oxygen is converted directly to electrical energy, Dr. C. E. Larson, research vice president, National Carbon Company (Parma, O.), division of Union Carbide, announced.

The first practical units, developed recently, are now supplying power for the operation of Army "silent sentry" radar sets.

Dr. Larson said the secret of the new fuel cell's success is the chemically treated, hollow, porous carbon electrodes through which the gases enter the cell and which also conduct the electricity produced by the electrochemical reaction.

Youth Wants More Lab Time and Science Projects

Youth Plans Science Education

by Shirley Moore

➤ After school science activities and inspired science teachers are two of the best ways in which the nation can bolster its science education. This is the opinion of 40 of the nation's top young high school scientists surveyed by Science Service.

From their personal angle as "consumers," these youngsters, each a top winner in the annual Science Talent Search for the Westinghouse Science Scholarships and Awards, have developed specific ideas of the high and low points in their own training and experience. Not surprisingly, however, although from varied backgrounds and schools, these young scientists agree substantially on what they feel has to be changed in our national science education program.

Expand Existing Programs

Over 60% of the answers mention encouragement and expansion of actively creative student programs as successful ways to find and develop more young scientists. These programs include science clubs, science fairs, the Science Talent Search, science congresses and seminars.

They feel that there should be more emphasis on science clubs and fairs, and that the fairs should be expanded to give more students an opportunity. According to a 16-year-old from Georgia, science fairs, congresses, and competitions such as the Science Talent Search should not only be made available, but should also be presented as "highly attention-demanding, appealing and attractive." There should be widespread organization of "school chapters of Science Clubs of America, Junior Academies of Science, and county-wide students' science councils to help present science to youth," says another young winner.

Still another student suggests that community interest which is expressed by "attendance at science fairs, newspaper publicity and other recognition encourages students to greater efforts."

An enthusiastic idea concerns science seminars, sponsored by the community, for "highly motivated students, chosen by the school, with scientists from local industry and educators from colleges."

Many of these students agree that scientists can accomplish a great deal by stimulating science club interest in careers in the sciences, mathematics and engineering. Science hobbies, they feel, should be emphasized in Boy and Girl Scouts, Camp Fire Girls, Y.M.C.A. and Y.W.C.A. programs. Civic clubs can perform a valuable service by sponsoring hobby shows and science fairs.

Top Scientists from Clubs

These youthful opinions on the effectiveness of extra-curricular opportunities are borne out by statistics. The careers of many of the country's

successful younger scientists grew out of their high school experience in science fairs and clubs or the Science Talent Search. Follow-up studies show that former Science Talent Search and National Science Fair winners are now represented in nearly every field of science. More than 50% have earned their doctorates; and among them they have published an astonishing number of scientific papers and books. Many have been honord by speecial grants and fellowships, and membership in scholarly societies is nearly universal.

Nearly 60% of the students are convinced that teachers are one of the most important factors in the production of potential scientists — more teachers, inspired teachers, better trained and paid teachers, teachers who keep in touch with practicing scientists and new developments in their fields.

Believing that a good science or math teacher knows how to draw out the best in a student and can introduce him to the idea and ideal of a scientific career, these young people sketch a word-portrait of such a teacher. He or she "inspires, not stifles" . . . gives "a sense of the freedom of science, instead of discouraging students by requiring pure mimicking, memorizing, and customary forms" . . . "emphasizes the new and undiscovered" . . . "glamorizes scientific fields."

Avoid Overglamorizing

But, on the other hand, science "should not be overglamorized. Once students become interested in science, they should be shown that science is not 'hocus-pocus oniontop', but that it is, instead, a lot of hard work — in order to avoid winning to science people who are quite unfitted for it." . . . "Science should be taught as a subject which is young and in which innumerable mysteries await discovery, rather than as an all-knowing subject in which nobody has a chance to discover anything new." . . . "There should be less learning of facts, cut and dried, and more encouraging of initiative. I think that if initiative precedes facts, the knowledge gained will be more thorough and profitable."

That there are hundreds of such gifted teachers is evident in the warm tribute paid them by students who have experienced their influence, enthusiasm and encouragement. Some 60% of the winners and honorable mentions in three recent Science Talent Searches and 37% of the finalists in three National Science Fairs attributed their developing interest in science and mathematics to an inspiring teacher or teachers.

That hundreds and thousands more such teachers are needed is underlined by the unhappy contrast drawn between these outstanding teachers and those who may be teaching science and math unwillingly, or without adequate training, or without ever having glimpsed the wonder and adventure of their subjects.

The survey shows that over 50% of the students emphasize the necessity and value of "selling" science and scientists to children, older students and people in general. The selling, they feel, should be accomplished not only by teachers, but by the entire school system, by scientists, by the press and by community enterprises.

Communications Media Can Help

A 16-year-old girl from New York State believes, for example, that the press can help by "creating interest in and appreciation of the work of scientists," which is widely misunderstood, and by helping "to dispel the belief that scientists are not normal people." She adds that movies and television should schedule "more educational pictures and shows similar to Disney's 'Our Friend the Atom'."

Another New Yorker, a 16-year-old mathematician, says, "Perhaps if science were more elevated in the public eye, and high scholarship as esteemed as excellence in sports, more young people would be attracted to professional careers as scientists."

A young girl from Oregon feels that "it often happens that a student who might be able to pursue a very satisfactory career in science is turned away by the conviction that science is an insuperably difficult subject." Ways must be found, she thinks, to "reach these students before the difficulty of science has become fixed in their minds."

A 17-year-old Illinois mineralogist comments, "Schools and communities which are interested in producing more scientists must first get a positive attitude toward the scientist as an individual." To which an 18-year-old girl adds, "By showing a positive interest in science, an atmosphere develops in a town which creates a feeling for science among both children and adults."

More than 40% outline concrete ideas on the desirability of accelerated, enriched, honor, and seminar courses in science and mathematics.

Want More Lab Experience

Many include the almost universal need for better equipped, larger laboratories and longer laboratory periods. In the usual laboratory period as now scheduled, one youngster said, "you just about have time to get your experiment set up, then it's time to put everything away so the next class can do the same thing!"

They comment that if all students can work to the limit of their capabilities there will be no boredom or repetitiveness in the classroom; that physics, chemistry and biology should be taken out of the "textbook course" category; and that acceleration might include allowing capable students to take junior and senior courses early in the curriculum, offering some college level science, or scheduling students to take courses at nearby colleges for credit.

A farsighted idea concerns an orientation course in the sciences for all non-science students, which would not only give them background for understanding current and future problems and developments, but might also uncover some latent and unsuspected science talent.

It is also suggested that science should be emphasized in high school graduation requirements and that an Advanced School be set up within the school, offering "science, mathematics and history taught by college methods," and that calculus, bacteriology, biochemistry, advanced physics and higher mathematics at least be introduced to advanced students.

Projects Find and Nurture Scientists

One-fourth of the group believe that projects are particularly fruitful means of finding and developing sci-

entists: the project method of teaching; seminars with individual projects; projects for fairs, Talent Search, clubs and for fun.

In recommending the science project method of teaching, it is suggested that it "often catches the unwilling!" Other ideas include industry's subsidizing projects for talented students, and help on projects from local institutions and scientists.

Almost 25% of the "Top Forty" are concerned with our lateness in introducing children to science, believing that science aptitude should be tested, identified, and supplied with facts and projects during early elementary grades.

Recognize Aptitude Early

It is proposed that each school should have at least one qualified science teacher to develop and supervise a science program for all third to sixth graders . . . that science and mathematics aptitude should be recognized by fifth grade . . . that qualified fifth and sixth graders be given work in elementary biology, atomic structure and astronomy . . . that "the natural curiosity of many young children should be stimulated in the early grades into an active interest in science through special classes for exploration and experimentation in various scientific fields" . . . that elementary teachers might welcome a visiting high school student as an aide, for an hour each week, to perform experiments and "fire the imagination of eager young minds."

One boy says frankly that "elementary schools should teach arithmetic well instead of merely exposing the pupils to it . . . general science should be taught in seventh and eighth grades in far greater detail than most schools now teach it."

Field trips to industries, laboratories, museums, planetariums, etc., were mentioned by several students as good interest-sparkers.

Well-stocked libraries and encouragement to read current books and magazines covering various aspects and fields of science were also recommended.

Individual members of the group commented on the importance of such influences as science lectures, church support and recognition of young scientists, and an atmosphere of encouragement and stimulation at home.

Few of us would quarrel with the suggestions and comments of these young about-to-be scientists. As a matter of fact, there are active projects going on all across the country to accomplish some of these changes and improvements.

However, if the total picture looks a little utopian, that is the kind of picture we have always depended on the younger generation to paint for us and each other!

Soil subsidence, the continual shrinkage of soil and lowering of its level, is the evidence that this highly organic material is oxidizing and disappearing into the air as gases.

Astronautics is not now limited to science fiction; it is a legitimate branch of engineering, and a number of major aeronautical concerns in the U. S. have already established astronautical divisions or departments.

Sees Laboratory Creation Of Human Body Organs

Need to Make Human Spare Parts

▶ CREATION in the laboratory of functioning glands or other organs for the human body to replace those removed because of disease may "ultimately" be achieved, Dr. Virginia J. Evans of the National Cancer Institute, Bethesda, Md., predicted at the Decennial Review Conference on Tissue Culture at Woodstock, Vt.

Rejuvenation by transplanting suitable laboratory-grown glands would even seem a possibility, although Dr. Evans did not mention this.

Replacement of failing human hearts by laboratory-grown ones would also seem a possibility.

Without specifying what organs might be created in the laboratory, Dr. Evans did point to the fact that tissue for repair operations is badly needed.

Cultivation of functioning gland tissue in the test tube for implantation, she also said, deserves concentrated effort in the near future.

The new kind of spare parts for the human body now foreseen will be built from pure strains of cells grown, or cultured, in the laboratory. The gland or stomach or kidney will not necessarily have the characteristic shape and form of the natural organ, but it will be able to function in the same way.

These laboratory created spare parts will be achieved through advances in the field of tissue culture, which has already provided the means of growing polio virus for vaccine production.

A better understanding of cancer and how it arises can also come, Dr. Evans pointed out, from study of living cells cultivated outside the body. Cancer, she said, seems in one sense to be a disturbance between the interrelated chemical processes of the cancer cells and those of the normal body cells. When the normal and the cancer cells are cultivated in the laboratory, scientists can learn exactly what chemicals are needed to nourish each kind of cell. They can learn, also, how each kind of cell affects the chemicals it lives in by just living and growing.

Slices of tissue, such as now cultivated in the laboratory, do not give as much basic information as is needed for solving problems of growth, both normal and cancerous. This is because the tissue slices are a mixture of cells. The food requirements and food handling of cell mixtures are probably different from that of the individual cells in the mixture.

Steps toward learning food requirements of individual cells have already been taken. Skin cells in pure strain from a 65-year-old man have been growing and reproducing rapidly for four months on a diet of known chemicals without any protein, Dr. Evans reported. Another pure strain of mouse skin cells has been kept in a state of relatively rapid growth and

reproduction for more than 21 months on chemicals without protein.

Once such cells, all the same kind, can be kept alive and reproducing in the test tube on a particular diet, scientists can add one by one other foods, to see how the cells handle these. The process, on a very small scale, is like that through which requirements for different vitamins have been learned. In both cases a basic diet is worked out and then substances added one at a time to see how the one extra substance affects the animal or the cell.

"Many if not most of the advances in animal nutrition have been motivated by sociologic and economic demand," Dr. Evans stated. "Tissue culture nutrition has now reached a stage of development where the same strong forces that have been seen in the development of animal nutrition will influence the future trends in nutrition of animal cells in vitro."

Lubricants To Perform at 700° F.

➤ Supersonic aircraft of the near future will require lubricants capable of good performance at temperatures up to 700 degrees Fahrenheit.

Walter W. Gleason of Esso Research and Engineering Company predicted that research now underway would solve the problem of lubricating future jet engines at such high temperatures.

The development of synthetic oils made from chemicals has already permitted aircraft engine designers to greatly increase power and efficiency. The generally good performance of the synthetic oils has enabled engine builders to raise bearing temperatures from 350 up to 500 degrees and lubricant temperatures by about 100 degrees.

Now the need for higher speed aircraft has required engine manufacturers to design and build a new class of powerplants which will feature greater outputs and higher overall temperature levels. The advent of these new engines will create new lubrication problems and will require development of products possessing new unique quality features.

"In addition to good high temperature characteristics," Mr. Gleason observed, "it is desirable that lubricants possess outstanding low temperature fluidity so that global operations of military equipment are possible. This permits operations from polar regions to the equator.

"As the operating temperatures of engines get higher and higher, it may be necessary to relax some of the low temperature requirements in order to achieve the necessary high temperature stability." If this takes place, he pointed out, planes would be designed to allow for a mechanical means of heating oil at low temperatures. A lowering of the requirements, he said, would permit consideration of many lubricating oil sources previously passed over because of poor low temperature properties.

Laboratory tests have shown, he said, that petroleum oils, which are relatively inexpensive and widely available, could be "very attractive for high temperature service."

For The Home Lab

Uric Acid From Urine

by Burton L. Hawk

➤ Uric acid is one of the most important nitrogenous waste or end products of animal metabolism. It is the chief nitrogenous product found in the excrement of birds and reptiles. It is also present in the urine of man and mammals. The daily excretion amounts to about 0.3 gram.

Under normal healthy conditions, uric acid occurs in the blood in amounts extending from 1 to 3 mg. per 100 ml. But sometimes things go wrong and additional uric acid is produced. This excess is deposited in the joints producing the painful condition known as gout. Or, it may collect in the gall bladder as gallstones. Gallstones usually consist entirely of uric acid or the monoammonium salt.

Uric acid is formed in the tissues by the destruction of nucleo-proteins which are first converted into purin bases by certain ferments. The purin bases are acted upon by other ferments and thus converted into uric acid. Some meats are rich in purin bases and thus their consumption increases the uric acid in the body and the urine.

Place 400 cc. of normal urine in a large beaker. Add 40 cc. of concentrated hydrochloric acid, stir, and allow the solution to stand in a cool place for 24 hours. At the end of this time small crystals of uric acid will have formed on the sides and bottom of the beaker. Carefully pour off the liquid leaving the crystals in the beaker. Wash the crystals down in the beaker with the smallest possible amount of water. Add a little boneblack or powdered charcoal and heat the water to boiling for about 5 minutes. Quickly filter the solution while hot. Then allow it to cool thoroughly. Crystals of uric acid will separate. Considering the quantity of uric acid present in urine, your yield will be small, but you should have a sufficient amount for the following tests.

As you may have deduced by now, uric acid is insoluble in cold water, but somewhat soluble in hot water. But the crystals will dissolve quite readily in sodium hydroxide or sodium carbonate solution. Dissolve a few crystals in a small quantity of sodium carbonate solution. Now in another container prepare a solution of silver nitrate. Dip a piece of filter paper in this solution. Place the wet filter paper in a watch glass and allow a few drops of the uric acid solution to fall upon it. The paper will turn grey. The silver nitrate has been reduced to metallic silver by the uric acid. This reaction is known as Schiff's test.

Place several crystals of uric acid in a watch glass. Moisten them with a few drops of dilute nitric acid. Evaporate the liquid to dryness by applying *very gentle heat.* Be most careful not to overheat. When the solid has cooled, add a drop or two of ammonium hydroxide. A purple

color is formed. This is due to the formation of murexide and is known as the "murexide test". If you now add a drop of sodium hydroxide solution, the color changes to blue.

Again dissolve a few crystals of uric acid in sodium carbonate solution. To this add a dilute solution of potassium permanganate. A brown precipitate of manganese dioxide is formed. In this reaction the permanganate is reduced by the uric acid.

Uric acid will also reduce Fehling's Solution. To a solution of uric acid in sodium carbonate, add a few drops of Fehling's solution. Note that a white precipitate is formed. This is copper urate. Continue to add a slight excess of Fehling's solution and then boil the mixture for several minutes. The red-brown precipitate of cuprous oxide is obtained. (Fehling's solution consists of two solutions which are kept separate until ready for use. They are then mixed in equal quantities and added to the solution to be tested. To prepare one solution, dissolve 1.5 grams of copper sulfate in 50 cc. of water. To prepare the other solution, dissolve 8.5 grams of sodium potassium tartrate (Rochelle salt) in 10 cc. of warm water. Add to this a solution of 2.5 grams sodium hydroxide in 10 cc. of water. Stir and dilute the mixture with 30 cc. of water).

If you can collect enough uric acid crystals, place a few of them in a dry hard-glass test tube. Heat gently. Note that charring occurs and a white sublimate is formed on the upper cooler parts of the tube. Thus, uric acid has no melting point but decomposes when heated. Use a little caution here, as one of the decomposition products of uric acid is none other than the highly poisonous hydrogen cyanide!

Uric acid has been synthesized, although there is no reason to prepare it in any quantity. Up to the present no one has found much of a use for it. But who can foresee . . . some day it may prove valuable in some way in which we have no conception now!

Chymia Resumes Publication

The publication of *Chymia,* an annual journal devoted to the history of chemistry, will be resumed in the spring of 1958.

The internationally known publication will be co-sponsored by the Edgar Fahs Smith Collection, University of Pennsylvania, and the Division of History of Chemistry, American Chemical Society.

The editorial board is composed of Dr. Henry M. Leicester, College of Physicians and Surgeons, San Francisco; Dennis I. Duveen, Duveen Historical Library; Sidney M. Edelstein, Dexter Chemical Corp., and the following representatives of the University of Pennsylvania: Claude K. Deischer, Murray G. Murphy and Conway Zirkle.

The board has named Dr. Leicester editor-in-chief, and all communications regarding submission of manuscripts and editorial information should be forwarded to him.

The publisher will be the University of Pennsylvania Press, Thomas Yoseloff, director.

Convert Heat Directly to Electricity

➤ An electronic device that converts heat energy directly into electrical energy has been developed by the General Electric Company, Dr. Guy Suits, vice president and director of research, has revealed.

The new device, a thermionic converter, "boils" electrons out of a hot metal surface to produce an electrical current. Experimental converters have changed over eight percent of the applied heat energy into electrical power, Dr. Suits said.

The converter was invented by Dr. Volney C. Wilson of the company's research laboratory, Schenectady, N. Y., and represents a unique combination of several principles long known to scientists.

In explaining his invention, Dr. Wilson compared the boiling of electrons out of a metal surface with lifting water to the top of a hill.

"If we let the water flow down the hill, it can do work — run a water wheel for instance — but only if we can provide a smooth, uninterrupted path down the hill. The thermionic converter essentially smooths the path of the electrons from a hot electrode to a cooler one and removes barriers which in the past have absorbed the energy before it could do useful work in an electric circuit."

Most methods of converting heat into electricity involve moving machinery, such as steam plant electrical generation or the heat of gasoline combustion expanding gases to operate a gasoline engine generator. Most previous methods of converting heat directly into electricity without intervening rotating machinery have been based on thermocouples. In such devices a junction between two different metals is heated and small electrical currents are produced. However, thermocouple efficiency is normally well below one percent.

General Electric officials emphasized that thermionic converters are "experimental laboratory devices only" and are not ready for production.

Mosquitoes Need Protein

➤ Mosquitoes need well balanced diets to reproduce satisfactorily. If their blood-food does not give the insects enough of the needed proteins, they will not have as many offspring as they could.

This is the conclusion of Dr. Dwight M. Delong, Arden O. Lea and John B. Diamond of Ohio State University, Columbus, Ohio.

The scientists gave yellow fever and malaria mosquitoes a variety of diets to see why those which feed on some animals lay more eggs than those which feed on others.

Numerous substances in sugar solution on saturated pads were fed to 200 fertile female Aedes mosquitoes for 16 days. Of the foods tested, only certain proteins or their derivatives stimulated egg production, the scientists reported.

The scientists are now studying the role of vitamins in mosquito reproduction.

Man-Made Diamonds Going Into Production

➤ MAN-MADE DIAMONDS, identical to the natural stones, will be in mass production for industrial users sometime next year, the General Electric Company's Metallurgical Products Department has revealed. More than 100,000 carats of diamonds already have been produced in pilot plant operations, Kenneth R. Beardslee, general manager of the department, said.

Synthetic production of industrial grade diamonds is expected to free the United States from dependence on Belgian Congo and South African supplies, Mr. Beardslee said.

Diamonds produced in quantity have been shown to be identical to natural diamonds on the basis of optical, X-ray and chemical examinations and hardness tests, the company revealed. The largest of the synthetic diamonds are about the size of coarse grains of sand, and most of them are about the size of fine sand.

The man-made diamonds, produced from carbon under high pressure and temperature in a duplication of the natural process, will be used in cutting tools, grinding wheels and other industrial equipment.

The present cost of the ungraded diamonds is $4.25 a carat, about 40% higher than the cost of ungraded natural diamonds, John D. Kennedy, manager of the diamond section, said. He added that expanded production facilities are expected to bring the cost down.

General Electric researchers emphasize that the man-made diamonds are not imitations, but are the same diamonds that nature produces except for size. Further research is expected to increase the size. The synthetic diamonds demonstrate all the variations of color, clarity and crystallinity found in naturally occurring diamonds, the scientists reported.

On the Back Cover

➤ A SCIENTIST *in the Olin Mathieson Chemical Corporation laboratory pilot plant at Niagara Falls, N. Y. is shown working on future fuels. This scientist is working in what is called the "glass laboratory" where advanced research on future fuels is carried out. It was in this laboratory that Olin Mathieson achieved a research breakthrough for production of HEF-2 and HEF-3 (High-Energy Fuel-2 and 3). Aircraft and missiles using new high-energy fuels have their range increased up to 50 percent. High-energy fuels are chemical fuels as opposed to conventional petroleum-based fuels.*

√ *Chemistry Quiz* √

Directions: Mark within the parentheses corresponding to the answer you think is *most nearly correct.* Answers are on page 26.

1. Which two of the following are *most* alike?
   ( ) 1. colloid and compound
   ( ) 2. emulsion and colloid
   ( ) 3. mixture and compound
   ( ) 4. solution and compound

2. If an unexposed photographic film is exposed to strong white light, the emulsion will immediately
   ( ) 1. bleach
   ( ) 2. bleach only if it has been immersed in developing solution
   ( ) 3. darken
   ( ) 4. darken only if it has been immersed in developing solution

3. Which of the following agencies of the U. S. Government would probably have the most complete information regarding the occurence of monazite?
   ( ) 1. Atomic Energy Commission
   ( ) 2. Department of Agriculture
   ( ) 3. Department of Commerce
   ( ) 4. Tennessee Valley Authority

4. The elements C, H and O are all found in every
   ( ) 1. alcohol
   ( ) 2. carbon oxide
   ( ) 3. hydrocarbon
   ( ) 4. nitrate

5. *Catenary* is a term used primarily in
   ( ) 1. chemistry
   ( ) 2. electronics
   ( ) 3. mathematics
   ( ) 4. zoology

These questions have been taken from Science Aptitude Examinations used in previous years as part of the annual Science Talent Search. Complete copies (with answers and norms) of many previous examinations are available at 10c each from Science Service, 1719 N St., N.W., Washington 6, D.C.

The aircraft industry has a machine that will whittle out winged shapes with micrometric precision.

A 40-foot-long shock tube to test ballistic missile designs produces shock waves which travel 17 times the speed of sound.

The total world catch of fish continues to increase and is now approaching 30,000,000 metric tons a year.

Most of the nation's supply of cranberries is produced in Massachusetts.

Red Students Better Trained

➤ A YOUNG RUSSIAN, when he enters a Soviet university, has five times more science and mathematics than the minimum needed to enter an American school like Massachusetts Institute of Technology.

Sputnik is a direct result of Soviet Russia's stressing the tough, hard subjects of mathematics and sciences.

Because of this intensive training, the Russians have a tremendous pool of well-trained secondary students from which it is easy to select future scientists.

Dr. Nicholas DeWitt of the Russian Research Center, Harvard University, Cambridge, Mass., told a conference on Engineering and Scientific Education-Foundation of National Strength meeting that Red schools teach in 10 years what we take 12 years to do.

With the American public aroused by sputnik, however, educators should be able to "sell" the necessity for a tougher curriculum and better training at all levels of education for U. S. high school students.

For 30 years Russia has been educating boys and girls in mathematics and science — subjects American students are so willing to shun. Now Mr. and Mrs. Average American may be awakened to the methods and achievements of Russian education.

The Russians pressure-cook their young students to suit the predetermined menu of the State. The United States permits its students to prepare themselves on an a la carte basis.

This, in essence, is the difference between the educational systems of the two nations as set forth in a 226-page illustrated book published by the U. S. Department of Health, Education and Welfare. The pre-sputnik study, entitled "Education in the U.S.S.R.," presents the most comprehensive report made to date on the Russians' educational mass-production.

"The report makes it clear that the Soviet Government is giving increased emphasis and support to education at all levels as an instrument to serve the political, military and economic goals of the Soviet State at home and abroad. It is also clear that Soviet education is making an increasing contribution to the Soviet objectives, particularly in science and technology," Lawrence G. Derthick, U. S. Commissioner of Education, said in releasing the book.

Cautioning that education as it is understood in the Soviet Union has no exact parallel in this country, Mr. Derthick warned that "it would be tragic, therefore, if the evolution of education in the U.S.S.R. should be considered as any cause to question our basic concepts of freedom in education."

Soviet education, the book reports, is the best mirror today for seeing "what a given culture considers important, what its expectations are, and in what direction it is heading."

The study, two years in the making and including material from both American sources and Russian sources, highlights these facts about Soviet education from pre-school years to post-doctoral training:

1. The Russians concentrate in ten years about the same number of

scheduled hours of instruction in their primary-secondary school set-up as the U. S. public schools do in 12 years. Russian schools are on a six-day-a-week schedule.

2. The Russians graduated 200,000 more high school students in 1956 than did the U. S.

3. The number of Russian graduates from colleges and universities has jumped four times in the last ten years.

4. The Soviet State attempts through its planning mechanism to decide the number of skilled personnel needed in various fields for the most effective development of Soviet power, whether it be ballet stars, athletes or scientists and engineers.

5. Schools are opened, approved and run by the State in Russia. The Government allocates educational facilities, controls the teaching staff, determines the methods of instruction and the curriculum, and selects textbooks.

The report also points out that the educational system is under the surveillance of the secret police.

In comparing the Russian educational system with ours the report states that although both systems employ the principle of free and universal education, "authoritarianism characterizes the Soviet philosophical base; the goal of education is to meet the needs of the State."

In the U. S., on the other hand, "constitutional representative democracy characterizes the philosophical base on which the people of the U.S.A. govern themselves. In theory and in practice, the individual is of surpassing worth and the goal of education is the development of each person as an individual with freedom and with opportunity to choose his life's work in his best interests."

Nobel Prize Winner Studied Life Particles

➤ The award of the 1957 Nobel Prize in Chemistry to Sir Alexander R. Todd, Scottish-born professor of organic chemistry at the University of Cambridge, England, for "his work on nucleotides and nucleotide co-enzymes" raises the question, "What are nucleotides?"

Sir Alexander himself explains the role of these fundamental life particles as follows:

When the complex nucleic acids found in all cells and tissues are broken down by the addition of water, "relatively simple compounds" called nucleotides are formed. They are phosphates of the "ribosides or 2-deoxyribosides of certain purine and pyrimidine derivatives."

The laboratory production of living matter is believed to be hinged on finding the specific structure of nucleic acids, the basic life substance.

Both nucleotides and nucleotide co-enzymes have a structure consisting of one or more units. Each of these units is composed of a combination of sugar, phosphoric acid and a base.

Sir Alexander, in the annual Harvey Lectures delivered in 1951 under the auspices of the Harvey Society of New York, said nucleic acids were so named because they were originally found in cell nuclei. They are now known to be normal constituents of all cells and tissues, and are associated with proteins as nucleo-proteins.

Educational System Needs Overhaul

A COMPLETE OVERHAUL of education in the United States to make it qualitatively competitive with Russia and Europe has been urged by Rear Adm. H. G. Rickover, chief of the Atomic Energy Commission's Naval Reactor Branch and assistant chief of the Navy's Bureau of Ships.

In a powerful indictment of the present educational system from grade school through college and graduate training, Adm. Rickover called for quality, not quantity, of graduates.

Launching of Soviet satellites, he told a Detroit conference on scientific education sponsored by the Thomas Alva Edison Foundation, Inc., was a "triumph of Russian education." The propaganda victory thus won by the U.S.S.R. should spark "drastic and long overdue reforms in utilizing the nation's intellectual capacities."

As Pearl Harbor showed that the U. S. could perform industrial miracles in a national emergency, so the Soviet's sputniks show the need for "educational miracles."

At present, Adm. Rickover charged, few American students at the age of 21 or 22 know as much after a four-year college course as most European secondary school graduates know at 18 or 19.

To remedy this, he urged establishment of uniform educational standards throughout the country. Since education is within the province of the states under our constitution, he suggested a private agency financed by all institutions of higher learning be set up to establish the standards.

National standards for the high school diploma, as well as for the scholastic competence of teachers, would be set by this agency. In this way, parents and local groups could tell whether or not schools were giving them a good return for their tax dollar.

Adm. Rickover also called for shortening the "general education" system to 14 years at most, and 12 to 13 years for brilliant children.

He said the Russians have built in record time an educational system that produces the trained professionals and technologists needed to achieve technological supremacy "day after tomorrow." The U. S. must be awakened to the dangers of its present educational system, and the prestige and material reward of professionals must be raised before this country can produce scientifically trained manpower competitive with the Russians.

"The rate of progress or decline of a country is so closely tied to the education" of its children that this rate depends on education, Adm. Rickover concluded.

√ Answers to CHEMISTRY QUIZ on page 23. √
1, 2; 2, 3; 3, 1; 4, 1; 5, 3

Fusion and
Stellar Temperatures

Polymers, Crystals and Plasmas

by DR. GUY SUITS
Vice President and Director of Research, General Electric Company

(Continued from CHEMISTRY, November, 1957)

PART III: Plasmas

▸ AS FAR BACK as anyone can remember in the arts and sciences, the attainment of high temperatures has been important. High and ever higher temperature continues to be a primary objective of modern scientific research in many fields, with significant technological progress dependent upon the results. Scientific news these days seems dominated by items about high-temperature alloys, high-temperature vacuum tubes and electronic circuits, high-temperature semiconductors, high-temperature strength in polymers, and — if you will excuse the expression — many other similar hot topics. Nowhere is this goal of high temperature more enticing and exciting than in the study of high-temperature gas plasmas. And nowhere are we talking about such high temperatures, since here techniques are emerging for heating gases to millions of degrees — temperatures that are known to exist in the stars but which have until recently not been available in the laboratory.

Control H-bomb Process

The primary objective of these techniques is to bring under control the process of the hydrogen bomb so that it can be peacefully employed for the production of energy. This process — called a thermonuclear reaction — works by fusing together light atoms to form heavier atoms, with a resultant release of energy. The fusion process is not only the basic process of the hydrogen bomb, but is also the accepted explanation of the prodigious energy production of the sun. The first public discussion of the possibility that the thermonuclear process might be controlled and used for energy production was made by an Indian scientist, Dr. H. J. Bhabha, at the Geneva Conferences on the Peaceful Uses of Atomic Energy in 1955. Subsequently, in April of 1956, the Russian scientist Kurchatov, speaking at the British Atomic Energy Establishment at Harwell, described experiments with stellar temperatures with controlled fusion as an objective. In July 1956, some U. S. work sponsored by the AEC was revealed in a paper by Dr. Richard Post of the University of California Radiation Laboratory.

From all of these sources there is now developing the outline, or at least a shadow, of future scientific discoveries potentially of great significance. Because many important scientific events in the past, for example the nuclear chain reaction, have cast a prophetic shadow in advance of

their arrival, there is a strong temptation to jump to the conclusion that the controlled thermonuclear reaction is practically here, or just around the corner. If that is the case, the announcement has not come to my attention. In any event, there is a little too much optimism in some quarters about fusion power, and one would be well advised to relax a bit and thoughtfully consider the nature of the discovery we contemplate will be made, and its possible consequences. And — most important — we should consider how long it will take for this proposed discovery to be felt at home. In this particular scientific challenge, the goal is so immense that there is a correspondingly great need to clearly delineate the difference between hope and accomplishment, for thus far research on a controlled fusion reaction has been much more productive of hope than of power. I am thoroughly convinced, however, that in the longer term these hopes cannot be denied and that eventually a reluctant nature must be made to yield a controlled thermonuclear reaction for energy generation. But vast harm can be done by a myopic view of fusion, and in the appraisal of this not-impossible technological event there is a clear need for perspective and balance.

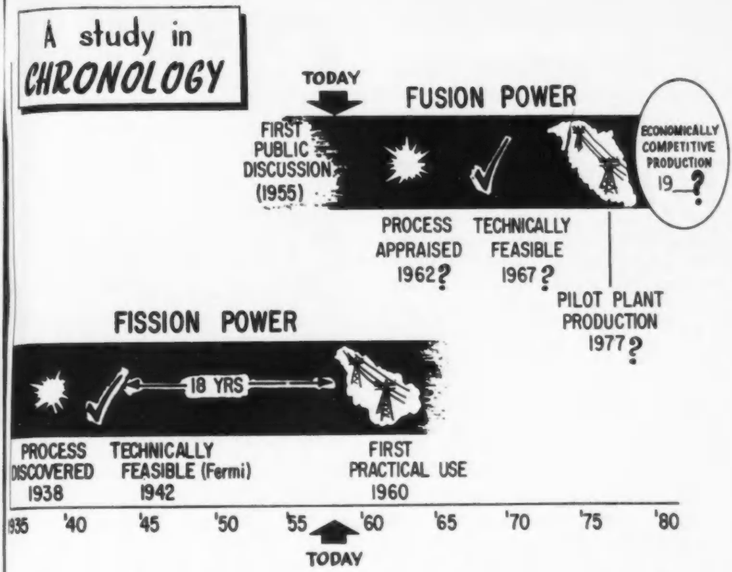
Chronology of Fission

For perspective, let us review the chronology of the fission, or atom-splitting, process, on which all present atomic power plans are being based. The process was discovered in 1938 and subsequently underwent intensive development in the atomic bomb project. The first appreciable consideration of the possible application of fission to power production dates from 1942, when Fermi's group actually accomplished a chain reaction. Extensive efforts and corresponding expenditures have been made since then to bring this older process of the atomic age to the start of practical use. The *start* of practical use will be approximately 1960. I am overlooking several earlier small-scale pilot power plants and also the important fact that the large-scale plants which will then be in production will at best show only marginal economy. Thus it will have taken approximately eighteen years to bring fission, as a technically feasible new energy process, from Fermi's laboratory to a position where power from Commonwealth Edison's Dresden station may begin to help light that historic room under the University of Chicago stadium.

Fusion Time-table

Now, let's look at the time-table for the hydrogen process. Since a technically feasible (not necessarily economically feasible) *fusion* process has not been announced, it is safe to assume that we are not yet at the starting point corresponding to 1942 in the fission process. Furthermore, it is a fact of technological life that a very long time is required to develop technically complex, large-scale power machinery, and the development of fusion, *after a successful process is in hand,* will be subject to this reality.

My own view is that (1) five additional years of research will be required to make possible a realistic appraisal of the fusion process, (2) in ten years we may be at the point of technical feasibility, and (3) pilot-plant production of fusion power will



not begin for twenty years. Competitive economic power production lies beyond that. In this picture there is a clear role for power production by fission in the near future, and power by fusion for the longer term. Fission power is technically feasible today, will rapidly become competitive with older energy sources, and is supported by a fifteen-year investment in specialized technology as a firm foundation for growth. The final phasing-in of fusion power, if it eventually becomes feasible, will be greatly facilitated by the accumulated atomic power experience of the utility industry, which by that time will add up to at least two, and perhaps three decades.

Fusion Examined

It is now appropriate to turn from the possible *chronology* of fusion to the *science* of fusion as it looks in the laboratory. To the researcher in the physical sciences, it would be hard to find a more fascinating and challenging problem than fusion. To bring stellar temperatures into the laboratory for study is a dream that, until recently, few astrophysicists would have had the courage to express. Yet the work already reported gives considerable substance to this dream. Perhaps the most important single concept so far is that of magnetic containment. At first sight it would appear to be impossible to contain a gas at a temperature of many millions of degrees, since all known materials melt and vaporize at very much lower temperatures. But stellar gas is a very special gas indeed, so much so that it has been referred to as a "fourth form of matter," to be considered

along with conventional gases, liquids and solids.

At room temperatures, common gases are electrically insulating—that is, they prevent the passage of appreciable electric current. As the temperature of a gas is raised, it becomes progressively a better electrical conductor because the gas atoms ionize and become electrical in character. This in itself is not new because an ionized gas as a conductor of electricity has long been an article of commerce. Ionized gas fills fluorescent lamps and generates the ultra-violet radiation which causes their phosphors to give off light. Ionized gas is the basis for a wide variety of electron tubes which are important in radio, TV, communication, industrial and military equipment. Finally, ionized gas plays a fundamental role in the interruption of circuits carrying electric current. In the large electric circuit breakers employed in power systems the ionized gas, or arc, is generally controlled by a magnetic field, and this fact is the clue to stellar temperatures.

➤ Dr. Henry Hurwitz *(right) discusses instrumentation on part of the General Electric Company fusion research project with Dr. W. F. Westendorp, designer of much of the experimental equipment. A giant bank of capacitors to produce large amounts of electrical energy in short bursts appears in the background.*

A gas at a temperature of a million degrees is an electrical gas. It is fully ionized — that is, each gas atom is an electrical charge carrier. This fully ionized or electrical gas is a good conductor of electricity (at ten million degrees its conductivity would be comparable to copper). It also can be controlled with a magnetic field. In this fact lies the hope of bringing stellar temperatures into the laboratory, and eventually of achieving a successful fusion reaction. The idea is to make a "magnetic container" that will hold a bit of cosmic plasma so that it never touches the walls; just how to do this still stumps the experts, and how to fill the container is another sticky problem to be worked out. And to make it more difficult, it isn't a million degrees, but 100 million degrees that we must have eventually. But we have a foot in the door, and in response to what will eventually become an overwhelming need, nature must, if at all possible, be made to yield a successful answer to this effort.

Fusion Research

In spite of the reservations I have mentioned about the length of time it may take to realize the goal of practical power from fusion, at our re-

search laboratory we are convinced that the ultimate importance of safe and inexpensive power from hydrogen makes it essential for us to study the problem right now. We have established at the General Electric Research Laboratory in Schenectady a substantial research program to study the fusion process. It would be presumptuous for me to compare the magnitude of our effort with that of the AEC's famous Project Sherwood, but we *do* expect to focus the traditional skills of the electrical industry on this primarily electrical problem. We believe it is important for both industry and government to be engaged in studying matters of such great importance to our future. Our work on fusion has been going on for over a year and is expanding. We do not yet have any results to announce publicly and — frankly — have no expectations of building fusion pilot plants in the near future.

As Dr. Henry Hurwitz, who is heading up our fusion program, has put it, "The processes for generating and containing a thermonuclear plasma employ magnetic fields, electric discharge phenomena, and power circuit design and current-handling methods. Fusion technology, as now conceived, thus employs the most basic technical skills of the electrical industry and it is inevitable that the industry can contribute heavily to this important development."

My ten-year-old friend may not have to look very far down the list of elements on the periodic table to find something to concentrate on. The very first on the list, and supposedly the "simplest," is hydrogen. Right now I'd be willing to bet that — if he wants to become an expert on hydrogen — when my young friend is looking over those 500 job offers in 1970 he'll find that one of them is from us.

New Courses in Practical Research Suggested

➤ A GRADUATE COURSE for scientists destined for industrial research is needed to teach them "how-to-do-it," and "how-to-use-it," Dr. Clifford F. Rassweiler told the Society of Chemical Industry.

The research director of the Johns-Manville Corporation outlined a new type research education to the Society as the recipient of its 1957 Chemical Industry Medal.

Dr. Rassweiler charged that the successful completion of current industrial research involves the application of knowledge and techniques in which the traditional methods now being taught cannot be applied. At the same time, "the development of the material and the character of its performance are dependent upon natural forces which are so obscure that neither chemistry nor physics has yet supplied a definition of the basic natural laws which control their behavior."

"More and more," he explained, "industrial research and university people ought to be considering a graduate degree, to be offered for a year of graduate study, specifically designed to teach the type of things important for industrial research."

Ceramics That Bend

➤ SUCCESS in obtaining ceramic materials that bend — an achievement that may mark a major breakthrough in the search for strong, light structural compounds to withstand high temperatures — has been announced.

Earl R. Parker, University of California metallurgist, said he and his colleagues have developed laboratory methods of treating some hopelessly brittle ceramic materials so that they can be bent through large angles without breakage. Magnesium oxide is the most "bendable" ceramic they have found so far.

The metallurgist reported his work in delivering the Campbell memorial lecture of the American Society of Metals at the Second World Metallurgical Congress meeting in Chicago.

Mr. Parker's work has been directed at combining desirable properties of both metals and ceramics. Ceramics are not affected by temperatures in the region of 3,000 degrees Fahrenheit, but they are very brittle. Metals have flexibility, but they become useless usually at about 1,700 degrees.

Noting the need in rockets, atomic energy and other fields, Mr. Parker stated, "it appears, on the basis of our research, that there is an excellent chance that a number of useful ductile ceramic materials will be developed within the next few years to satisfy the urgent demands of Government and industry."

Mr. Parker said that greatly improved mechanical devices have been designed but remain unbuilt because of the lack of the right materials. He blamed an inadequate understanding of basic physical processes of materials for the lag in metallurgy.

Millions of dollars have been spent in recent years in trial and error efforts to find new materials. Mr. Parker said this Edisonian method has virtually no chance of success in this day of rapid scientific advance. Only a basic science approach has a chance of paying off, and the work at Berkeley represents such an approach.

Find New Fallout Danger

➤ ANOTHER potentially deadly compound, manganese-54, has now been found in radioactive fallout, adding to the already existing danger from strontium-90.

The discovery of the radioactive manganese was reported by Drs. William H. Shipman, Philip Simone and Herbert V. Weiss, U. S. Naval Radiological Defense Laboratory, San Francisco, Calif.

Manganese is a metallic trace element found in small quantities in human cells, and it is believed to be necessary for normal cell life.

Its presence in radioactive fallout was revealed when a fallout sample was found to be giving off gamma rays with the same energy as those known to come from radioactive manganese. Chemical analysis proved that the unknown substance was manganese-54, and calculations showed that large quantities of it were produced at the time of bomb detonation.

The discovery again emphasizes the importance of considering induced radioactivities in fallout, the authors reported.

Toxic New Fuels Hard To Spot

➤ Tiny traces of highly dangerous jet and rocket fuels based on toxic boron compounds are hard to spot with present equipment, a meeting of the Industrial Hygiene Foundation has been told.

The future of boron hydrides, very toxic compounds that provide the "kick" in new exotic fuels, was hitched to development of proper safety precautions by Dr. William H. Schechter, vice president for operations, Callery Chemical Company, Callery, Pa.

A serious problem of exotic fuel manufacturers, Dr. Schechter said, is the lack of monitoring instruments capable of detecting trace amounts of boron hydrides around plants and laboratories. The maximum allowable concentration of one of the boron hydrides, diborane, has been set at one-tenth of a part of diborane per million parts of air breathed daily. However, Dr. Schechter pointed out that present instruments can not reliably detect such small concentrations, and diborane can be detected by odor down to only three or four parts per million.

Dr. Schechter said the main effect of breathing diborane, a gas at normal temperatures, is damage to the lungs. Its toxicity can be compared with that of phosgene poison gas of World War I fame.

Two other boron hydride components of high energy fuels appear to have more drastic effects, Dr. Schechter said. They are decaborane, a solid, and pentaborane, a liquid that is easily converted to a gas. These fuel components attack the central nervous system and also cause damage to the liver and kidneys, Dr. Schechter said. Symptoms of overdose include loss of coordination, convulsions, weakness, tremors and extreme excitability.

Details of high energy fuels are classified, but it is believed decaborane figures most prominently in exotic fuel manufacture.

Dr. Schechter said safety programs of exotic fuel manufacturers depend on avoiding contact with boron hydrides. Laboratory studies are usually carried out in fume hoods in which exhaust fans rapidly change the air. Because the compounds are highly explosive as well as toxic, many plant and laboratory rooms are constructed of three steel walls and one "soft" wall that will easily blow out during an explosion, Dr. Schechter reported.

Rocket Projects Next

➤ The editors of CHEMISTRY will start off the new year with a bonus for the many readers who have asked "What kind of safe chemistry project can I perform in the field of rocketry?"

Featured in the January, 1958, issue of CHEMISTRY will be a discussion of several types of student rocketry projects that introduce the student to the methods of professional chemical research.

Chemical Memory Computers

➤ MILLIONS OF microscopic cells containing photosensitive liquid may provide the first practical chemical memory for computing machines.

A laboratory demonstration of a large-scale prototype that prints, reads and erases information on the photosensitive film was held at the dedication of the new engineering and research center of the National Cash Register Company, Dayton, Ohio.

The technique of encapsulation forming "solid liquids" by composing droplets of liquid a millionth of an inch in diameter in gelatin film and then coating them on paper or other substances was described by Stanley C. Allyn, chairman of the board.

The company's scientists, during 12 years of research, have developed new oils or dyes called metachromic dyes. When a blue light shines on them, they turn a brilliant blue. When a yellow light shines on them, they become colorless again. This chemical switch can be made and erased indefinitely.

By putting these dyes in a capsule of microscopic size — containing millions of droplets per square inch — they can be handled like solids and used for computing machine memories.

Similar to magnetic tapes now being used, the chemical memories have the advantage of eliminating spreading. They also promise computers with high storage capacity, high access speed and low cost. Ideally, 1,000,000 bits of information could be stored on a square inch.

The same technique has provided National Cash Register Company researchers with a commercial carbonless business form. As the key of a typewriter strikes the paper coated with these tiny droplets, the cells break, leaving a print.

It is also foreseen that the same techniques will provide a means of printing, with magnetic characters that can be read by both people and machines, and will be used in pharmaceutical practice for keeping reactive compounds separate in tiny droplets.

The company hopes to have a working model of its chemical memory computer in a year and a half, Mr. Allyn said.

English Sewage, African Soil Give Same Antibiotic

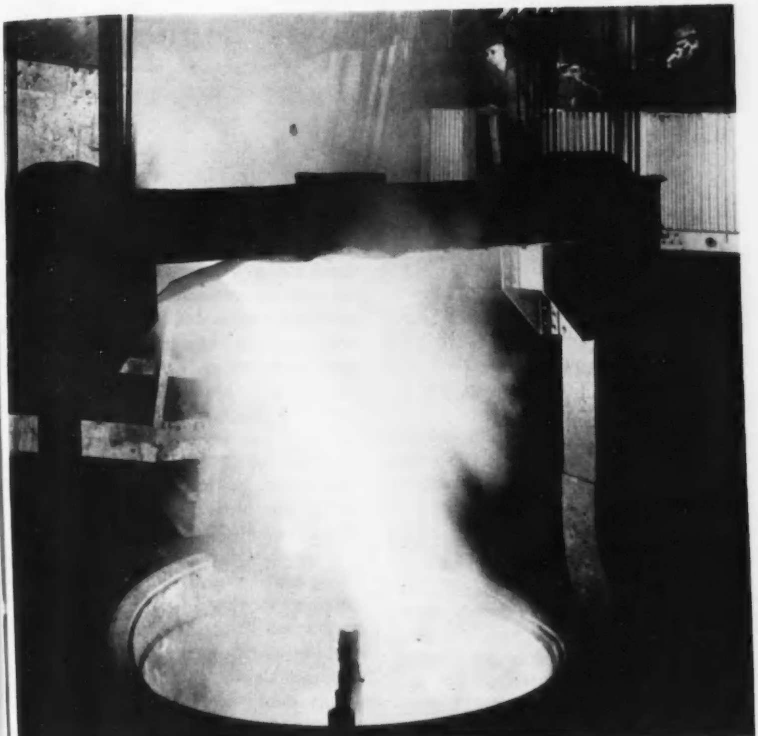
➤ SEWAGE from Oxford, England, and soil from East Africa have yielded the same or a very closely related antibiotic.

The Oxford sewage antibiotic is called micrococcin because it came from germs of the Micrococcus family.

The East African antibiotic came from germs of the Bacillus pumilus group. The name micrococcin P is now suggested for it, since its close relation, if not identity, with micrococcin has been discovered.

Studies were reported by Drs. E. P. Abraham and N. G. Heatley of the Sir William Dunn School of Pathology, Oxford, and Drs. P. Brookes, A. T. Fuller and James Walker of the National Institute for Medical Research, London.

Steel, New and Old



➤ A 50-TON ELECTRIC FURNACE *is tapped at a Republic Steel Corporation Canton, Ohio, plant. The molten mass shown here will become stainless steel.*

A
CHEMISTRY
SPECIAL SECTION

Three Processes For Direct Reduction of Iron Ore

Steel Without Blast Furnace

From Industrial Bulletin of Arthur D. Little, Inc.

➤ THE steel industry may soon learn how to produce granular iron cheaper than pig. This is the aim of current experiments on direct reduction of iron ore — actually a revival of primitive practice, where batches of ore and charcoal were simply heated together in an open pit. Current developments involve removal of oxygen from iron ores by heating them together with hydrogen or some other reducing gas. The resulting reduced iron is pressed into briquettes, which are then charged into the steel furnace.

The blast furnace, now six hundred years old, embodies one of technology's first continuous processes. Reduction of ore in the blast furnace, using coke for heat and carbon monoxide produced as it burns for the reducing agent, has been the historical basis of steelmaking. As our economy pushes south and west, however, convenient supplies of good coking coals are increasingly difficult to find. Furthermore, blast furnaces and their associated coking ovens are becoming more costly; today, economic units are so large that they represent a considerable financial outlay.

Direct Reduction Flexible

Today's largest blast furnaces will produce 2000 tons of liquid iron per day. But since the Duquesne furnace of 1895, few changes, other than the introduction of pressurizing and improvements in materials handling, have been made. What actually happens inside a blast furnace is known to be very complicated, but the tremendous capacity of the unit has left no room for argument, and on this basis alone, its usefulness has rarely been questioned. Because it uses special grades of coke, the blast furnace is limited geographically. Steelmakers feel that direct reduction, which can be independent of coke, offers far more flexibility; a plant could be located wherever there are supplies of gas, oil, or any ordinary non-coking coals. Direct-reduction units, moreover, could be constructed more economically. Small plants could be as efficient as large ones, and estimates claim that a 1000-ton-capacity unit could be built at half the $30 million needed for its blast furnace counterpart.

The steelmaker refers to his raw materials in terms of "iron units," now available from pig iron, iron ore, and scrap. Scrap, from steel mills as well as outside sources, has been a handy pivot material, with which manufacturers could readily compensate for shortages of other raw materials. But the price of scrap is climbing (40 per cent within the last year) and fluctuating widely, and the in-

dustry would welcome a substitute. In this application, the iron produced by direct reduction has possibilities. Even if it were used to replace just enough scrap to hold over-all cost of iron units steady, markets for this reduced iron could grow considerably, without shutting down a single blast furnace.

Direct reduction is not new; historically, it has had several trials—all unsuccessful and costly. Of several techniques investigated, none could remove all impurities from the ore, nor could they compete with the volume turned out by the blast furnace. But newer versions of the process are claimed to have overcome these shortcomings. Either using pure ores, as now, or lower grades, they will likely produce iron of acceptable quality. Secondly, they operate efficiently, employing a fluidized-solids technique developed just before World War II. This technique originated in the oil industry, and has effectively simplified catalytic petroleum cracking. It is based on the principle that if gases are blown through a powder, the mass behaves as a liquid and produces excellent gas-solid contact.

Interest in direct reduction has been stimulated by the discovery of some unusually pure sources of iron ore in Venezuela, Brazil, Liberia, and elsewhere abroad. Furthermore, new ore-processing mills in Minnesota are turning out ores of almost equal caliber from low-grade hard taconite that has been broken into fine pieces and upgraded by magnetic separation. The new ores, many of which are already powdered, are ready-made for direct reduction, but would have to be sintered or pelletized before they could be used in a blast furnace.

Direct reduction has been given another boost by the development of three new reducing gas generators that provide hydrogen at low cost from a wide variety of carbon fuels, such as coal, natural gas, fuel oil, or even asphalt. New processes— steam-methane reforming, partial oxidation, and coal gasification—have replaced the traditional, high-cost method of obtaining hydrogen from coke, and can make reducing gases, rich in hydrogen, at a cost of approximately \$5 to \$10 per ton of iron produced. The cost of coke is higher—about \$11 per ton of iron.

Three Possible Processes

Three fluid-bed processes are being considered, all differing as to operating temperature, pressure and nature of the reducing gas used. One, operating at 900° F, uses pure hydrogen as a reducing gas, at about 400 psi pressure. A second process, in the range 1200-1500° F, also operates on hydrogen, but at 50 psi. For the third process, using a mixed gas derived from natural gas, pressure is about atmospheric, and temperature is in the range 1400-1700° F. The first of the three is a batch process; the other two are continuous. There are relative advantages and disadvantages to each, and considerably more work remains to be done before any of the three processes can be settled upon as best suited to a given ore.

Whatever the outcome, it appears that the steel industry, through new technology, will soon have an important source of supplemental iron.

What Are Stainless Steels?

by Joseph Winlock
Chief Metallurgist, The Budd Company, Philadelphia, Pa.

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➤ The stainless steels comprise a large group of alloy compositions having in common a relatively high degree of resistance to corrosion. Essentially, they are alloys of iron, carbon and chromium — although many of these steels contain, in addition, manganese, nickel and other alloying ingredients.

Today there are 37 types of stainless steel designated by the American Iron and Steel Institute, while there are literally hundreds of other stainless alloys available commercially under various trade designations. The number of these alloys has grown rapidly in recent years, largely due to the drastic need for new materials of construction for aircraft, atomic reactors and missiles. At the same time, there has been a decided increase in the use of stainless steel for general industrial and domestic use, as the properties of these steels have become better known and as their utilization has become more attractive economically.

As might be expected, this period of rapid growth has brought about some confusion as to properties, characteristics and applicability of the various stainless alloys — especially the newer ones. Unfortunately, we find that the term "substitute" — with its implication of inferiority — is being carelessly applied, where the word "alternate" might be a more apt choice. In the last analysis, the preference of one particular stainless alloy over another one only has real meaning when its properties are measured against the minimum requirements for a given application. When two or more alloys qualify, the consideration of cost will generally prevail.

The engineer or designer who is faced with making selections among the multitude of structural materials now available to him will be well advised to familiarize himself with the whole family of stainless steels — including some of its newer members. Not only design improvements but substantial cost savings may be possible through the intelligent selection of these steels.

Early Development Work

The fundamental differences between the various stainless groups can perhaps best be illustrated by a review of their history. The art of steelmaking itself is, of course, an ancient one and even alloy steels were known in Biblical days. The discovery of stainless steel is, however, a distinctly modern development and was an immensely important milestone in metallurgical history.

The discovery is generally credited to the English metallurgist, Harry Brearley, who in 1912 was experimenting in an attempt to find a steel for the lining of guns, which would be more satisfactory in resisting the erosion and corrosion caused by the hot gases given off by the exploding powder.

Brearley reasoned that hardness and a high melting point would be among the desirable properties of the required alloy. He turned his attention to the metal chromium, which had long been known as a hardener for steel, and he made a series of alloys based on ordinary carbon steel with additions of up to 12% chromium.

These additions did indeed produce progressively harder steels, which could be forged and heat treated just as ordinary carbon steel. But at about 12% chromium a surprising change occurred: the corrosion resistance of the alloy showed a very pronounced improvement.

The many uses of such an alloy, with its very great resistance to corrosion, were evident to Brearley and he started at once to find alloys which were even more corrosion resistant. Two avenues of approach appeared as the most logical and metallurgically sound. The first was to make a series of steels in which the carbon content was markedly lower, since carbon is known to impair the corrosion resistance of steel. The second was to increase the chromium content. His final series of alloys were of the approximate chemical composition: 0.10% carbon, 18.0% chromium, and, since all steels contain the metal manganese in various amounts, Brearley's alloys contained some 1.00% maximum of this metal. The remainder — about 80.9% — was, of course, iron. From this series were developed the first true stainless steels.

It should be noted at this point that the corrosion resistance of stainless steels of this type is essentially a chemical and not a metallurgical property. The chromium is believed responsible for the formation of a thin, strongly adherent coating of oxide on the steel surface which is exceedingly effective in preventing further oxidation. As will be seen later, this film also tends to improve the resistance of chromium stainless steels to scaling at elevated temperatures. Moreover, it resists the corrosive effects of a number of chemical reagents which are very harmful to ordinary carbon steel.

Subsequent experience with alloys of the type discovered by Brearley has established that 12% is the practical minimum content of chromium needed to provide "stainless" properties.

Ironically, Brearley never succeeded in developing the gun barrel lining which he sought. But, of far greater importance, he succeeded in laying the groundwork for the commercial development of two of the three principal classifications of modern stainless steel.

Ferritic Stainless Steels

It will be seen that the end member of Brearley's series, which contained 18% chromium and 0.10% carbon, is a ferritic stainless. This composition is the forerunner of what is today known by the AISI designation of Type 430. It is very widely used in the automotive industry and accounts for the greatest tonnage of stainless produced today.

The high chromium and low carbon contents of the ferritic stainless steels assure satisfactory corrosion resistance. These steels retain their bright finishes, and their usefulness in automobile trim is obvious. Since they do not harden substantially upon quenching, and are not materially affected by heat treatment, fabrication is relatively uncomplicated.

Some of the drawbacks to steels of this type are (1) they are not structurally stable at high temperatures, (2) they are not tough, and (3) for certain applications, they are not hard enough.

When Brearley first developed his stainless steels, there was little interest in the ferritic alloys, because of their inability to be hardened. On the other hand, a hardenable stainless would be of value in the manufacture of cutlery and surgical instruments. Brearley set out to find a suitable composition.

Martensitic Stainless Steels

Brearley's cutlery steel, which was eventually a commercial success, had the approximate composition: 13% chromium and 0.35% carbon. By our previous generalization, this steel should be martensitic, and it is. Through proper heat treatment, these stainless steels can be made very hard and will hold as good a cutting edge as plain carbon steels.

Today's Type 420 stainless steel corresponds to Brearley's alloy and it is still used in the manufacture of cutlery — although it has given way in most instances to the Type 440 which is used in the highest quality ware, and which is simply an improvement over Brearley's original development.

The martensitic stainless steels are more difficult to fabricate than the ferritic steels. They require careful heat treatment, but will develop good hardness and toughness. Their high temperature properties are reasonably good, both with respect to structural stability and resistance to scaling. They are not as corrosion resistant as the ferritic stainless steels.

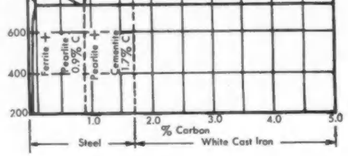


Figure 1

➤ *Iron-Carbon Equilibrium Diagram*

For the purpose of this article, it is convenient to divide the stainless steels into three classifications: ferritic, martensitic and austenitic. These terms, familiar enough to the metallurgist, are perhaps puzzling to the layman. They can best be explained by a consideration of the phase relationships which exist in the iron-carbon system.

The iron-carbon equilibrium diagram is shown in Figure 1. The material known as steel is arbitrarily defined as those compositions containing less than 1.7% carbon. Above this amount, and up to 5.0% carbon, the material is termed "white cast iron".

Of immediate interest to us is that area of the diagram to the extreme left, in which the carbon content varies from 0 to 0.9%. The vertical line at 0.9% carbon passes through the eutectoid and corresponds to the composition of pearlite. Pearlite is a mixture of ferrite and iron carbide (cementite).

Ferritic steels, in this simple system, are characterized by low carbon content; that is, these compositions approach that of pure iron.

Related steels in the martensitic stainless group are used in valves, bearings and other highly stressed parts where moderate corrosion resistance is also required.

Cr-Ni Austenitic Stainless Steels

Just before World War I, Dr. Benno Strauss, in Germany, was searching for a steel that could be used in temperature-measuring apparatus which would more effectively resist scaling at high temperatures. It was well known that the metal nickel imparted this property to steel, and accordingly Strauss added nickel in different amounts to one of Brearley's stainless steels. After considerable research he developed an alloy having the approximate chemical analysis: 18.0% chromium, 8.0% nickel, 0.12 carbon%, and the remainder, 73.88%, iron. The modern equivalent of this steel, which now contains some 1.5% manganese, is known as "18.8" (18% Cr.-8% Ni) or by the AISI designation, Type 302.

Strauss found that this steel not only effectively resisted scaling at high temperatures, but he also found that it possessed other unique and useful properties, such as a very high resistance to atmospheric corrosion and to many chemical media.

Metallurgically, it is known as an austenitic steel, so named for the famous English metallurgist, Sir Roberts-Austen. Due principally to the effect of the high nickel content, and to the sluggish diffusibility of chromium, the alloy, after cooling rapidly from a high temperature, consists of a solid solution of the different constituents in gamma iron. This solid solution is called "austenite." This

. . . (Courtesy of Foote Mineral Co., Philadelphia, Pa.)

On the other hand, as the carbon content of the steel is raised and the composition approaches that of pearlite, the steels become "martensitic".

It will be noted that the term "martensite" is not to be found in the iron-carbon diagram. If a composition corresponding to 0.9% carbon is cooled rapidly from its melting point, the high temperature form of steel known as "austenite" will first appear and will exist as the principal phase until a temperature of 725°C. is reached. At this point, the austenite theoretically should all be transformed into pearlite.

From a practical standpoint, this transformation will go to completion only if the time of cooling is very slow. If the steel is quenched, or allowed to cool rapidly in the air, a considerable amount of austenite will be retained. The austenite will subsequently transform to martensite, which will constitute the final structure.

Further heat treatment of a martensite steel will alter the relative proportions of the phase present. Prolonged annealing below the critical transformation temperature of 725° C. will effect a complete transformation to pearlite, whereas heating to higher temperatures and rapid quenching will encourage martensite formation.

Ferritic steels are not affected so much by heat treatment, for the simple reason that the transformation from austenite to ferrite and pearlite is relatively complete regardless of the conditions of cooling and the steels are therefore metallurgically stable.

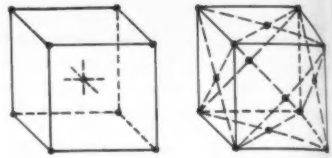
The addition of chromium, even in large percentages, does not alter the essential phase relations shown in this diagram – that is, there is a given carbon content which will produce either ferrite or martensite – depending upon whether the heat treating properties are desired or not. From a practical standpoint, however, 16% chromium is a rough dividing line between the ferritic and the martensitic steels – the ferritic steel having 16% or higher chromium content, and a low (0.12% or less) carbon content.

means that tne steel has the same structure at room temperature as ordinary carbon steels and the other stainless steels have at temperatures above their allotropic transformation. Another way of stating this is, that "18-8" stainless steel has no "critical range" during which allotropic transformation (changes in arrangement of the atoms in the space lattice) takes place on heating and cooling. In short, the addition of the metal, nickel, has caused the steel to behave as though its critical range were depressed to temperatures below room temperature.

For all practical purposes the alloy may be considered as a perfectly stable material, but the austenite, being in an undercooled condition is, from a physical-chemical point of view, in metasable equilibrium. It is unstable in respect to its allotropic condition and in respect to carbon solubility. It has been shown, for example, that when this alloy is cold worked at room temperature, some of the gamma phase is transformed to the alpha phase. The extent to which this occurs is, of course, dependent not only upon the amount of cold deformation, but also upon the exact amounts of alloys present.

Structurally, austenite differs from ferrite in that it has a face centered cubic lattice, while ferrite is body centered cubic (see Figure 2). It is significant that austenite is non-magnetic whereas the low temperature forms of steel display magnetism. The transformation of steel from the high to the low temperature forms can therefore be detected by a change in magnetic properties (see Figure 1).

When austenitic steels are cold



A, Body-centered cubic lattice. B, Face-centered cubic lattice.

Figure 2

worked, there is an increase in magnetic susceptibility indicating that austenite is being transformed to ferrite. Very drastic under-cooling (as in liquid air) will also induce this transformation in some austenitic alloys.

This metallurgical instability is used to effect an increase in physical properties by cold rolling, cold drawing, etc., and the importance of being able to change the physical properties in this manner cannot be over-emphasized. It is true that all metals and alloys may be cold rolled to higher tensile strengths, but few can undergo such treatment without an accompanying severe loss in ductility. The physical properties of this steel in the annealed condition are such that very high yield strengths and tensile strengths may be obtained by cold rolling, and at the same time sufficiently high ductility is maintained to form the steel into useful shapes.

Ductility is, of course, also essential in any material to be used for structural purposes, because any tendency toward brittleness would lead to early failure in service. It is to be realized, of course, that an exact balance between the amounts of the different constituents must be established and maintained in order to have at one and the same time maximum yield strength, maximum tensile strength

and adequate ductility. It is the complicated interrelationship between the carbon content, the nickel content, the manganese content, the nitrogen content and the effect of these elements on the structure of these steels upon which their metallurgy depends.

As a result of much research, it was found that the higher the nickel content, the greater is the reduction in thickness by cold rolling necessary to produce a given tensile strength. Where a high strength and a high ductility are needed, a low nickel content was found to be best. It was found, too, that the amount of carbon present acted in the reverse manner; i.e., the higher the carbon content the less is the reduction by cold rolling necessary to produce a given tensile strength.

From the preceding, then, it may be inferred that to produce, by cold rolling, the maximum ductility for a given tensile strength, the nickel content should be low and the carbon content high. Whereas, if a steel for deep drawing is desired, for which a low rate of work-strengthening is an advantage, a high nickel content and a low carbon content is indicated.

So, by evaluating the influence of each element and the different combinations of these elements, several different alloys were developed, each one of which has a specific range of chemical analysis, but all falling under the general classification of the 300 Series stainless steel. They vary only in the amount of each element.

Ordinary austenitic steels cannot be hardened and strengthened by heat treating, since they retain their austenitic structure even upon annealing. However, the addition of small quantities of certain elements upsets this metastable condition and an austenitic steel will undergo transformation into a martensitic structure under heat treatment.

Such steels are known as "precipitation hardening" steels — and the advantage in employing them is that they can be formed or shaped in the annealed ("soft") condition and then heat treated to the desired physical properties.

The 300 Series stainless steels are characterized by their excellent resistance to corrosion. Since austenitic steels consist of but one phase (ferritic and martensitic steels have two), there is a tendency to minimize attack by corrosion. They are tough, strong and resistant to scaling in high temperature service. Although newer alloys have been developed for high temperature service, 18-8 stainless steels have been widely used for their heat resisting qualities. Their cold working properties permit fabrication by a number of methods, and they may be deep drawn with good results.

This combination of properties makes the 300 Series stainless steels useful in the fabrication of high strength structural members, such as railroad cars, truck trailer bodies, aircraft parts, and architectural siding. Because of their corrosion resistance they find use in the chemical, food processing and dairy industries for various units and components in the processing equipment.

Austenitic Cr-Ni-Mn Stainless Steels

At the beginning of World War II, metallurgists were confronted with the prospect of a decreasing availability of the metal nickel and by the desire to conserve and utilize our nat-

➤ In the transportation field, *stainless steels are widely used in the construction of railroad cars, truck trailer bodies, and tank trailers. Automobile trim accounts for one of the largest tonnage uses.*

Photo Courtesy of the Budd Co.

ural resources to their fullest extent. Since nickel is the element in "18-8" stainless steel which makes the steel austenitic, and since austenitic steels possess certain valuable physical properties not possessed by the other stainless steels, it can be seen that in order to conserve nickel, other elements producing the same metallurgical effect had to be investigated.

It had long been known that the metal manganese has very much the same metallurgical effects on steel as does the metal nickel; that is, when manganese is added in increasing amounts to a ferritic stainless steel, austenite results. Indeed, the so-called "Hadfield" austenitic manganese steels had been in existence for many years. They were and still are widely used where resistance to wear is of importance, but, since they contain no chromium, are not corrosion resistant. These steels contain about 12.0%

manganese, and about 1.0% carbon.

It was a logical step, therefore, to remove half of the nickel from "18-8" stainless steel and to replace it with manganese. The resultant stainless steel was called "18-4-4". It was later found that since manganese is not so strong in forming austenite as nickel, slightly more of this metal had to be added. The alloys which were finally adopted contain about 6.0% manganese and 0.12 to 0.25% nitrogen.

It has been found by experiment, and substantiated by many years of experience, that this series of stainless steels is a very valuable addition to the ever increasing number of stainless steels.

The austenitic chromium nickel manganese stainless steels just described, are known commercially as the "200" Series.

For all intents and purposes, the 200 Series stainless steels (AISI Types 201 and 202) are perfectly interchangeable with their 300 Series counterparts, Types 301 and 302. The general advantage in employing 200 Series instead of 300 Series is that there is a saving in cost. Furthermore, 200 Series stainless steels employ only half the nickel required for the 300 Series — and for this reason are less subject to shortages in times of critical nickel supply.

Experience with the 200 Series has been comparatively recent (since the beginning of World War II), but the cost of manufacture has steadily decreased and there is hope that additional savings may ultimately be passed on to fabricators. At the same time, as knowledge of these steels has grown, 200 Series stainless steels have found new uses of their own, in which their particular properties have been utilized to advantage. Stainless steel valves and piston rings of unusual wearing properties have recently been developed around 200 Series stainless steels.

Austenitic Cr-Mn Stainless Steels

The increasing need for steels and other alloys for high temperature applications has markedly increased in recent years, and in the belief that these needs would continue to increase, steps have been taken to develop further the austenitic chromium manganese stainless steels. Such research was necessary not only to conserve further strategic materials, but also to broaden the scope of our knowledge of the stainless steels.

It had long been known that nitrogen, along with nickel and manganese, helped to form austenite in the chromium stainless steels. Accordingly, a series of steels containing different amounts of chromium, manganese, carbon and nitrogen was made and the properties of these steels carefully investigated.

A commercial stainless steel of this type now available to fabricators shows the following approximate analysis:

Cr	17.0%	Si	1.0% max.
Mn	14.5%	C	0.1% max.
N	0.4%		

The nickel content is limited to a maximum of 1.0%, which is the amount remaining as a residual in the "scrap" ordinarily used in the making of steel.

Much research has definitely proved that the austenitic chromium manganese stainless steels have as valuable and as useful properties as the austenitic chromium nickel stainless steels and the austenitic chromium

nickel manganese stainless steels. In general, they are characterized by higher yield and tensile strengths.

While they currently find limited use due to their newness, the chromium-manganese stainless steels should find applications in railway car bodies, truck trailer bodies and food and chemical processing equipment.

Summary

From a metallurgical point of view, no two steels are exactly the same. There are always some physical properties which are different. Any sound evaluation or comparison of one steel with another cannot therefore, be made by considering one physical characteristic without considering others as well. For example, resistance to corrosion in certain media is one of the attributes of the stainless steels, and because of this they are often compared and evaluated on the basis of the results of such tests; yet many of the corrosive media used for test purposes will never be encountered in service. In every application sound metallurgical judgment should be used and careful investigations should be made concerning the exact requirements needed or desired in the finished product.

New Developments in Steels

➤ A STRATEGICALLY-SCARCE metal used to improve high temperature steels can be replaced in part by a more plentiful metal without affecting desired high temperature characteristics.

Strategic molybdenum is normally used to make special steel alloys stronger at very high temperatures. Paul Shahinian and Dr. Joseph R. Lane, Naval Research Laboratory scientists, have found more plentiful vanadium can replace most of the molybdenum without reducing the strength at 1100 degrees Fahrenheit of most alloys commonly used in high temperature operation.

Mr. Shahinian told CHEMISTRY the scarcity of molybdenum fluctuates with world conditions and current needs. He said the research was performed "with the idea of finding out whether the substitution would be possible in the event of a molybdenum shortage during an emergency."

Niobium Improves Steel

A little-known metal, niobium, believed to be a major key in the development of steels for future engines and nuclear reactors, has been produced in its purest form by Westinghouse Electric Corporation scientists.

Perfection of a technique to provide enough pure niobium for detailed study of its properties is expected to bring the metal a step closer to its use in power plants of tomorrow.

New alloys based on niobium are foreseen as holding up well at temperatures above 1,800 degrees Fahrenheit, more than 100 degrees beyond the maximum operating temperatures of the best existing engine and reactor structural materials.

Westinghouse scientists purify the metal by repeated meltings in a nearly perfect vacuum. The high temperature and low pressure distills impurities out of the metal. The work on

the "wonder metal" is being done in cooperation with the U. S. Air Force's Wright Air Development Center.

"Super Magnets"

Experimental magnets with "one track minds" promise to be the first really permanent magnets which will resist having their magnetic alignment taken away by every method except high temperatures.

The new magnets are made by putting an oxide coating over very small particles of a magnetic material such as cobalt metal. The particles, when packed together at low temperatures in a strong magnetic field, form a very powerful magnet that cannot be demagnetized by another magnetic field working against the first.

The magnets are said to exhibit the phenomenon of "exchange anisotropy," producing effects never before seen in permanent magnets, and the first new magnetic anisotropy seen in 60 years, reported the discoverer of the magnetic substances, William H. Meiklejohn of the General Electric Research Laboratory in Schenectady. Anisotropy is an effect in magnets that causes them to have certain "easy" north-south alignments of magnetization.

The rare effect was found to be caused by the oxide coat on the metal particles, which though unaffected by magnetic fields, can at low temperatures pull metal atoms into magnetic alignment. Like railroad tracks, the metal oxide molecules keep the adjacent metal particles "magnetically aligned," but their effect is only good at low temperatures, which favor the oxide's orderly, magnetic "track-like" orderly themselves, and can no longer structure. At higher temperatures, the rows of oxide molecules become disinfluence the metals.

At present, Mr. Meiklejohn is working on other materials which show promise as anisotropic substances, and hopes that they will exhibit exchange anisotropy at room temperature or higher.

Magnetism Turns Corners

A new kind of steel that allows magnetism to go around corners has been announced.

The silicon and iron magnetic material, developed at Westinghouse Research Laboratories, Pittsburgh, Pa., is expected to simplify construction and improve performance of electrical equipment.

Dr. Clarence Zener, Westinghouse research director, called the new steel a "major scientific breakthrough for the electrical industry." He attributed the successful climax of the 25-year search for such a material to the steel's crystal orientation which allows it to be magnetized in four directions simultaneously.

Steel now used in magnetic cores can be magnetized in two directions only, back and forth along the direction in which it was rolled by the manufacturer.

The Westinghouse research grew out of work originated by scientists of the Siemens-Halske Co., Hanau, Germany.

Book Condensations

UNSTABLE CHEMICAL SPECIES: Free Radicals, Ions, and Excited Molecules —Henry C. Thacher, Jr., Ed.—*New York Academy of Sciences,* Annals Volume 67, Art. 9, 223 p., illus., paper, $4.00. The behavior of unstable species is of great practical importance in the design of nuclear powered aircraft and satellites.

GAS CHROMATOGRAPHY — A. I. M. Keulemans, edited by C. C. Verver with a foreword by A. J. P. Martin — *Reinhold,* 217 p., illus., $7.50. Discussing normal practice in this field and also the theory behind them.

VAPOUR PHASE CHROMATOGRAPHY: Proceedings of the Symposium Sponsored by the Hydrocarbon Research Group of the Institute of Petroleum Held at the Institution of Electrical Engineers, London, of 30th May-1st June, 1956 — D. H. Desty, Ed., assisted by C. L. A. Harbourn — *Academic,* 436 p., illus., $12.00. In addition to papers presented at this symposium, the volume contains recommendations on nomenclature.

POLYETHYLENE — Theodore O. J. Kresser — *Reinhold,* Plastics Applications Series, 1, 217 p., illus., $4.95. The status of applications at this time and a little history and projection to give perspective.

EPOXY RESINS: Their Applications and Technology — Henry Lee and Kris Neville — *McGraw-Hill,* 305 p., illus., $8.00. Covering the chemistry of the preparation of epoxy resins and their applications in industry.

GLASS REINFORCED PLASTICS—Phillip Morgan, Ed. — *Philosophical Library,* 2d ed., 276 p., illus., $15.00. Revised and partly rewritten. Discussing the chemistry of these plastics and many applications in industry.

CHEMICAL ANTHROPOLOGY: A New Approach to Growth in Children — Icie G. Macy and Harriet J. Kelly — *University of Chicago Press,* 149 p., diagrams, $3.75. Report of a study of average healthy children over a period of years.

HANDBOOK OF CHEMICAL DATA — F. W. Atack and Dan R. Atack, Eds. — *Reinhold,* 629 p., $6.75. A convenient reference work for chemists.

ELEMENTARY PRACTICAL ORGANIC CHEMISTRY: Part II, Qualitative Organic Analysis — Arthur I. Vogel — *Longmans, Green,* 668 p., illus., $4.50. Intended to place at the disposal of students of all grades the long experience of the author.

PROTEOLYTIC ENZYMES AND THEIR CLINICAL APPLICATION — Gustav J. Martin, consulting Ed. — *New York Academy of Sciences,* Volume 68, Art. 1, 244 p., illus., paper, $3.50. The most important of the proteolytic enzymes of animal origin are pepsin, trypsin and various of the intestinal juices.

BIOLOGICAL APPLICATIONS OF INTRARED SPECTROSCOPY — Robert P. Bauman, Consulting Ed. — *New York Academy of Sciences,* 253 p., illus., paper, $3.50. There has been a dramatic growth of infrared spectroscopy over the last decade. The editor predicts that within a year or so the infrared spectra of solids may be useful in proving the mysteries of crystal lattices.